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ENGINEERING *AT CASTLE BROMWICH*

THE ENGINEERS' DIGEST

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IN THIS ISSUE

THE British Industries Fair, to be held in Birmingham and London, from May 2nd-13th, will open its doors once again to a splendid array of exhibits presented by British firms. The tremendous national importance of the occasion obviously calls for special emphasis in our journal, and, therefore, we have had to depart somewhat from our usual editorial coverage in order to accommodate descriptions of outstanding products to be shown at the Fair. It is hoped that these will assist our readers in appreciating the ever increasing demands made on British industry, and the corresponding endeavours of suppliers of goods and services in Great Britain to meet such demands. This applies especially to the efforts being made to fulfil the requirements of the overseas markets, and it should be clear from our review of some of the exhibitors' displays that, as in previous years, high standards in manufacturing technique and in finished products are being maintained and improved. In particular, many new developments have been made in numerous fields of engineering, and visitors to the Fair will be afforded an excellent opportunity to see for themselves how magnificently this country is upholding its prestige in the world markets.

* * *

The investigation of spot welds by fatigue tests, the first instalment of which was published in our March issue and which is concluded in this issue on page 120, was financed by the Welding Research Council, Fatigue of Spot Welds Committee, New York, and carried out by the author, Prof. G. Welter, with the part-time assistance of a mechanic, who prepared the specimens and adjusted them in the fatigue machines. The fairly new subject matter of the experiments may be summarised as follows :—

Spot-welded aluminium alloy specimens as well as stainless steel and mild steel specimens have been investigated with regard to their metallographic structure and mechanical properties, both in the " as-received " condition and after treatment of the spots under high hydrostatic pressure. Because of serious difficulties encountered in the production of sound spot-welded aluminium alloy sheets of 0.064 in. thickness on a Standard Spot Welder, a non-destructive X-ray method for distinction between sound and defective spot welds had to be developed. This identification of sound welds before testing proved very useful for improving the efficiency of these prolonged fatigue tests, although, unfortunately, minor imperfections of the spot could not be revealed by this method ; such a deficiency may to some extent falsify the final results. This was avoided, as far as possible, by destructive test methods, by which a fair assessment of the influence of those minor imperfections could be made. It was, therefore, possible with the aid of radiographs of each weld to select mostly sound specimens for investigation under fatigue test conditions ranging from zero to maximum tensile loads. These tests revealed that an appreciable increase of the endurance limit of spot-welded alloys is possible if, after welding, the spots are subjected to high hydrostatic pressure. This pressure was gradually increased to 230,000 psi, and at 10,000,000 cycles, an improvement of 250 to 300 per cent of the fatigue resistance of certain alloy specimens appeared to be quite possible.

For obvious reasons, only part of the interesting figures, graphs, etc., of the original paper could be reproduced in our abstract, but it is hoped that we have nevertheless succeeded in giving the reader a true impression of this painstaking and valuable investigation.

* * *

Turbo-compressors of the conventional type, regardless of the number of stages, are arranged on a single horizontal shaft. In such compressors, the clearance losses and windage losses are greater than those which would result if there were no necessity to aim at keeping machining costs within economic limits. It is, therefore, of interest to consider ways and means of improving efficiencies without increasing manufacturing costs. In the Naumann compressor, this appears to be achieved by a number of measures, described in the article " A New Centrifugal Compressor " on page 110.

The distinguishing external feature of the Naumann compressor is its vertical axis. This however, is not the fundamental point. Its essential difference from conventional designs lies in the separation of the stages. Each impeller has a different speed, which is the theoretical speed appropriate to each particular stage. This in itself implies greater stage efficiencies. The design measures adopted are, in addition, conducive to achieving smaller clearances and reduced machining costs. Bearings take the form of stationary stub axles fitted into recesses in the hubs of the impellers.

A New Centrifugal Compressor

By A. NAUMANN. (From *Die Technik*, Vol. 3, No. 9, September, 1948, pp. 574-580, 10 tables, 7 illustrations.)

GERMAN design of large centrifugal compressors has remained fundamentally unaltered for the past 40 years, the individual impellers being mounted in a row on a single horizontal shaft. Though occasional designs with more than one shaft had already given improved efficiencies before the first World War, the few firms producing centrifugal compressors have hitherto adhered to the more favoured single-shaft arrangement. It would be a great mistake to conclude, however, that with this single-shaft arrangement, a stage has been reached where little further improvement can be expected as regards working efficiency and economy in manufacture. This report indicates how such improvement can be obtained, and compares a compressor of a new design with one of conventional design and equivalent performance.

The present-day method of construction of multi-stage centrifugal compressors with a single shaft has two fundamental drawbacks associated with it, and involves a large number of machining operations as well as unnecessarily large friction and other losses.

These two drawbacks are as follows:—

(1) The impeller shaft bends under the weight of the impellers and also to a greater or less degree as a result of out-of-balance centrifugal loading. Deflection due to these two factors necessitates increased clearances in order to avoid, under all conditions, rubbing of the labyrinth seals.

(2) It is not possible to choose the optimum rotational speed for each individual impeller independently of the others, since all the impellers are keyed to a common shaft. The optimum rotational speed for a given volumetric flow through one stage is determined by the stressing of the impeller, the loading of which is mainly centrifugal. Thus, the rotor speed is determined by that of the first stage impeller, on account of the high volumetric flow through it, and the dimensions of the subsequent stages must be made successively smaller, corresponding to the progressive compression. To produce a given overall compression, it is necessary to have a definite sum total of the individual values of u^2, but each stage can only contribute to this total by an amount proportional to the square of its diameter relative to that of the first stage impeller. The necessary number of stages, then, is greater than would be the case if each impeller operated at the same peripheral speed u, or at its optimum rotational speed.

The above two fundamental drawbacks can be eliminated if we provide a separate stub-axle type of bearing for each individual impeller. The designer is thereby freed from the necessity of providing large clearances, and at the same time can now choose the optimum speed and diameter for each rotor. The validity of the above arguments is proved by comparing the new type of compressor with an older design of nine stages, having a compression ratio of 7 : 1 and an intake volumetric flow of 40,000 cubic metres per hour. The rotational speed is 3820 rpm, which corresponds to a maximum tip speed of 250 m/sec (4450 rpm and 290 m/sec under overspeed conditions). This latter figure can be regarded as permissible for an impeller with a central hole passing right through it (225 mm dia.), and therefore, an impeller with a bore of 60 mm dia. not passing right through it can be considered quite safe up to tip speeds of 300-320 m/sec. The new type of compressor impeller can be driven at such speeds with complete safety, since even with the stub-axle mounting arrangement, there are no bending stresses in the rotor at all. The layout is shown in Figs. 1 to 3, with vertical axis of rotation.

It can be said from experience that for a 7 to 1 compression, the sum of the values of u^2, for the different stages, must be about 350,000. The figure for the older design of compressor used for comparison is 360,000, and this same value is taken as a basis for the new design. The design data for the new compressor are given in Table I and the calculated friction losses in Table II. These are for the four individual stages of the compressor and are given by $N_R = 1{\cdot}6\, D^2\, u^3\, \gamma \times 10^{-6}$ in horse power. For comparison, the pressures and temperatures for the nine stages of the old-type compressor are given in Table III, and the corresponding

TABLE I. DESIGN FIGURES

Stage	1	2	3	4
Impeller diameter mm	730	620	540	520
n rpm	7,870	9,180	10,620	11,015
u m/sec	301	298	300	300
u^2	90,600	88,800	90,000	90,000

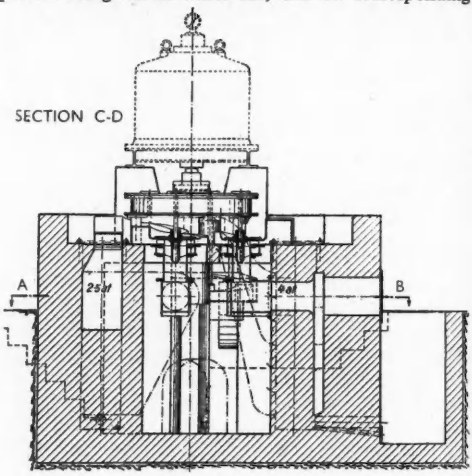


Fig 1

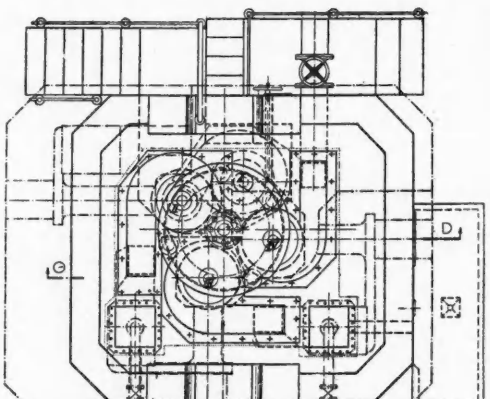
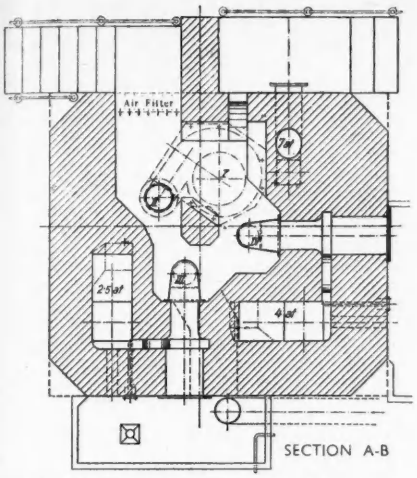


Fig. 2



Figs. 1-3. **Four-stage Naumann compressor.**

friction losses in Table IV. It will be seen that the losses for the new four-stage design are 193·6 hp compared with 251·5 hp for the conventional nine-stage compressor under the same conditions, i.e., the older compressor has 81·7 per cent higher friction losses.

The clearance leakage losses are also compared. These are found for each stage from the equation for flow through an orifice in a thin wall. The leakage figures for the old-type of compressor can be summarized as follows:—

8 shaft seals	0·255 kg/sec
9 impeller seals	0·854 kg/sec
1 balance piston	0·160 kg/sec
Total ..	1·269 kg/sec

The total mass of intake air of this conventional compressor is 13·45 kg/sec, so that the leakage represents 9·5 per cent. A further 0·5 per cent must be allowed for leakage through the impeller casing and diffuser joints which open slightly due to distortion under internal pressure. Hence, the total leakage losses are 10 per cent of the mass flow.

The leakage figures for the new compressor, calculated from the stage pressures and temperatures are as follows:—

Lower hub labyrinths (stages 2, 3 and 4)	0·056 kg/sec
Two impeller seals for each of stages 1 to 4	0·735 kg/sec
Total ..	0·791 kg/sec

This total figure represents 5·9 per cent of the compressor mass flow; thus, the leakage loss for this new compressor is only 59 per cent of the loss for the older design. The total saving in power (taking into account friction and leakage losses) of the new design over the old one, based on the input power figure of 4,500 hp, is 343 hp.

A further advantage of the new design is that after intercooling, the air is passed directly to the inlet of the next stage without coming into contact with any hot surfaces, which would produce losses due to reheating. Cooling can also be made more efficient, since the diffuser can be surrounded by cooling water and cooling begun immediately after the air leaves the stage.

Since, in the Naumann compressor, each impeller has a different speed, it is necessary to provide gearing between the drive and each rotor. Each gear set has only to transmit a quarter of the total driving power and only small masses have to be accelerated, so that changes of speed are rapid. It should be noted that the fundamental difference in the Naumann layout (compared with conventional designs), is *not* that the axis of rotation is vertical, but that as a result of the separation of the stages, the bearing for each lies in its own hub. Since each such bearing takes the form of a stationary stub axle fitting into a drilled recess in the hub of the impeller, any centrifugal (out-of-balance) loading, or weight loading (if the axis is horizontal) can be taken by a pressure oil film in the plane of application of such loading. This is the main point about the new design,

Table II. Calculated Friction Losses for the Four Stages

Stage	1	2	3	4
D = impeller diam. mm	0·730	0·620	0·540	0·520
D^2	0·5329	0·3844	0·2916	0·2704
$u^3/10^6$	27·271	26·464	27	27
Density at stage outlet kg/m³	1·55	2·35	3·79	6·15
$N_R = 1{\cdot}6D^2u^3\gamma/10^6$ hp	36·0	38·2	47·6	71·8

The total for all four stages is $N_{R_{tot}}$ = 193·6 hp for 40,000 m³/hr air aspirated and a 7 to 1 compression.

Table III. Pressures and Temperatures Through the Older Type of Compressor

Stage	1	2	3	4	5	6	7	8	9
Pressure before impeller p_s ata	1·02	1·474	1·944	2·553	3·158	3·89	4·625	5·305	6·15
Temperature before impeller °C	15	63	37	74	37	66	90	37	61
Density before impeller γ_s kg/m³	1·21	1·50	2·142	2·515	3·48	3·90	4·36	5·85	6·30
Pressure at p_{LA} ..	1·336	1·827	2·363	2·997	3·66	4·393	5·12	5·88	6·75
Temp. impeller t_{LA} ..	47	93	62	97	56	82	105	53	73
Density outlet γ_{LA} ..	1·428	1·71	2·413	2·77	3·80	4·23	4·64	6·16	6·67
Pressure after stage p_d ata	1·494	2·004	2·573	3·218	3·91	4·645	5·365	6·17	7·05
Temperature after stage t_d °C	63	107	74	108	66	90	113	61	80
Density after stage γ_d kg/m³	1·475	1·803	2·54	2·89	3·94	4·37	4·76	6·32	6·83

Table IV. Calculated Impeller Friction Losses for the Same Intake Volumetric Flow and the same Compression.

Stage	1	2	3	4	5	6	7	8	9
D = impeller dia. m ..	1·25	1·20	1·10	1·05	0·95	0·90	0·85	0·80	0·78
D^2	1·563	1·44	1·21	1·103	0·9025	0·81	0·7225	0·64	0·6084
u at 3,820 rpm .. m/sec ..	250	240	220	210	190	180	170	160	156
$u^3/10^6$	15·63	13·88	10·65	9·26	6·86	5·83	4·91	4·1	3·8
Density .. kg/m³ ..	1·43	1·71	2·41	2·77	3·8	4·23	4·64	6·16	6·67
$N_R = 1{\cdot}6\,D^2u^3\gamma/10^6$ hp ..	55·7	54·3	49·6	45·2	37·6	31·9	26·4	26·1	24·7

The total for all nine stages is $N_{R_{tot}}$ = 351·5 hp for 40,000 m³/hr intake flow, with 7 to 1 compression for horizontal axis of rotation above critical speed, i.e., 351·5-193·6 = 157·9 hp = 81·7 per cent more friction loss than with new Naumann compressor.

as opposed to conventional ones, in which no support is given at the centre of mass of each impeller.

The driving motor can be mounted horizontally or vertically, and accessibility of the compressor for servicing (cleaning, etc.) is good. The reluctance of some firms to operate compressors at high rotational speeds is unjustified in the case of the new compressor, since the bearing and gear speeds are kept within limits which have been proved safe by the experience of reliable firms over a long period. The figures for radial clearance used for calculating leakage losses were chosen carefully according to conditions in practice. No definite statement can, however, be made as to their applicability in general, since clearances are determined in practice by trial and error, i.e., by repeatedly taking off more metal after successive trial runs, during which the places where fouling occurs are determined. It should also be noted that only the actual clearances existing after a short period of running are to be considered as affecting compressor performance and losses.

It only remains to remark on a few design details of the Naumann compressor. The underside of each impeller hub is provided with a drilled cylindrical recess which fits over the stub axle, and lubricating oil under pressure is fed through an axial hole to a flat-ended annular two-surface bearing half-way up, which takes the weight of the impeller and any unbalanced thrust loading. The upper end of the impeller hub is connected to its splined driving shaft which is geared to the shaft of an electric motor or steam turbine. The cylindrical upper casing of the impeller is fitted with an easily removable three-stage labyrinth or stuffing-box seal, the upper end of which is connected to the inlet space of the first stage impeller. The impeller clearance can be made to 0·15 mm, before assembly, and no further machining or other work is necessary.

CZECHOSLOVAKIA

Breakdown Oscillograms of Oil Impregnated Paper

By J. Brablc. (From *Elektrotechnicky Obzor*, Vol. 12, No. 13/14, June 15, 1948, p. 275, 4 illustrations.)

Two types of breakdowns occur in insulating materials. One is the thermal breakdown, which develops slowly. It begins by deterioration of the power factor, which slowly grows from an initial value of 1-2 per cent to 5-10 per cent, and then leads to a breakdown in a short time. The second type, the electric breakdown, is an instantaneous phenomenon. The insulating material shows no change in its properties previous to the breakdown. The time leading to the breakdown depends on the magnitude and character (whether surge, d.c. or a.c.) of the voltage, and can be of the order of 10^{-6} to 10^{6} sec.

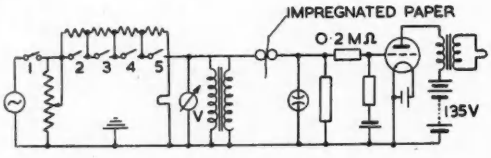


Fig. 1.

A definition of the expression "instantaneous breakdown" seems to be called for. Oscillograms of the breakdown of good quality 2·5 mil oil-impregnated cable paper have been taken. Fig. 1 shows the arrangement. As the breakdown strength of the paper is not uniform throughout, the tension was applied successively by starting with 4-5 kV and raising the voltage by 0·5 kV every 3-5 periods by switching-on with the switches (1) to (5). The breakdown generally occurred after 20 periods. The current coil was connected through an amplifier, which increased the sensitivity and, at the same time, protected the coil at the moment of the breakdown. Although the amplifier caused distortion, the oscillograms were useful. The breakdown was instantaneous when the capacity of the sphere gaps was greater than 20 pf, as shown on Fig. 2 and the capacitive current changed into an ohmic current in half the time of one period.

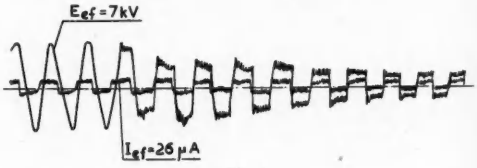


Fig. 3.

The oscillograms were different when the gap formed by two crossed wires was used. The capacity of this arrangement is much smaller. The breakdown oscillogram in Fig. 3 with a capacity of 12 pf shows that the breakdown takes 7-10 periods, while the loss angle increases to 90 degrees. Fig. 4 shows the oscillogram of the breakdown of two impregnated papers in a 4-pf gap between two needles.

By using a needle gap of very small capacity, it has been possible to eliminate the influence of those parts of the insulator which are not damaged initially by the impending breakdown and maintain a good loss angle almost until the complete breakdown. The small capacity gap shows (as in Figs. 3 and 4) a progressively deteriorating loss angle before breakdown, with a corresponding change of the capacitive current to an ohmic current.

It is considered that the so-called instantaneous electric breakdown also progressively develops as a thermal breakdown. The difference between the two types of breakdown is only quantitative. It also follows that the value of breakdown tests is limited.

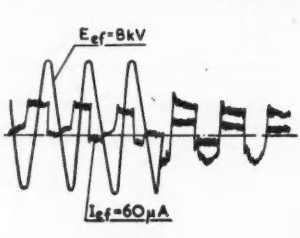


Fig. 2

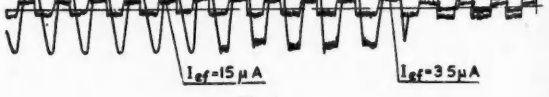


Fig. 4

Project for a Railway Track suitable for Increased Speeds

By L. La Magna. (From *Tecnica Italiana*, Vol. 3, No. 4, July-August, 1948, pp. 182-185, 2 illustrations.)

The highest speeds so far attained on Italian railway lines have been of the order of 120 mph with electric trains. The question is whether the existing tracks can be modified to allow heavy train traffic at these high speeds.

The ideal solution would be to replace the gravel ballast by a layer of reinforced concrete, as shown in Fig. 1. However, this is an extremely costly project which cannot be carried out under present conditions.

The project which will now be considered endeavours to retain as much as possible of the existing track. The proposed track arrangement is shown in Fig. 2. The ballast and rails are laid in place in the usual manner, but, in addition, a number of U-shaped supports of reinforced concrete are provided. The horizontal sections of these supports are laid 25 cm (10 in) below ground level, while the vertical arms carry horizontal members, also of reinforced concrete, at their upper extremities. These members run parallel to the rails, and are designed to prevent any vertical or lateral displacement of the sleepers.

The distance between the U-shaped supports should be approximately 5 metres (16 ft 5 in). The concrete horizontal members form a continuous lateral reinforcement of the track and ensure that the thickness of the ballast layer used shall be constant along the track. The line will thus have uniform elastic characteristics throughout its length. Play between the sleepers and the concrete horizontal members is prevented by hard wood wedges. The ballast is of the normal type with a Winkler coefficient of 10 kg/cm² per cm. Standard sleepers are used. The rails are of the new type F.S. 49, 36 m (118 ft) long for main lines, and connected to the sleepers by indirect clamps.

The rails should preferably have welded joints, assembled according to the suggestions made in Corini's report (see Bibliography).

CALCULATION

If the rails used are joined together without gaps, it is necessary to determine the stresses occurring in the rails, assuming there is no lateral deflection.

The calculation will be based on steel rails of type F.S. 49, in accordance with Italian Railway specifications. These rails have an ultimate strength of 7200 kg/cm², so that, if a safety factor of 3 is assumed, the safe stress will be $\sigma_s = 2400$ kg/cm². This stress should only be reached when the thermal stresses due to maximum temperature variations act simultaneously with the stresses due to maximum loads. Taking dynamic effects into account, the maximum load for one wheel can be assumed to be equal to 10,000 kg.

The maximum bending moment under a wheel is, according to Zimmermann

$$M_{max} = \frac{Pd}{4}\,\frac{8\gamma + 7}{4\gamma + 10} \quad .. \quad .. \quad (1)$$

In this formula $P = 10{,}000$ kg, $d =$ distance between centre lines of sleepers $= 65$ cm, $\gamma = 6EI/(0{\cdot}9\,C\,b\,l\,d^3)$, where $E =$ elasticity modulus of steel $= 2 \times 10^6$ kg/cm² ; $I =$ moment of inertia of rails relative to horizontal axis $= 1797$ cm⁴ ; $b =$ width of sleepers $=$ 26 cm ; $l =$ half-length of sleeper $= 130$ cm ; $C =$ Winkler's coefficient, assumed to be equal to 10 kg/cm² per cm. Substituting numerical values, we obtain $\gamma = 2{\cdot}58$, and hence $M = 221{,}000$ kg cm.

The maximum stresses at the flanges of the rail are, therefore,

$\sigma_1' = 221{,}000 \times 72{\cdot}9/1797 = 900$ kg/cm² (tension),

$\sigma_1'' = 221{,}000 \times 75{\cdot}1/1797 = 925$ kg/cm² (compression).

For the thermal effects, the following stresses will then still be available

$\sigma_2' = 2400 - 900 = 1500$ kg/cm² for a decrease in temperature,

$\sigma_2'' = 2400 - 925 = 1475$ kg/cm² for a rise in temperature.

If the coefficient of thermal expansion of the rails is $\alpha = 12 \times 10^{-6}$, the permissible temperature variations corresponding to the stresses σ_2' and σ_2'' are

$$\Delta t' = \sigma_2'/(E\alpha) = 1500/24 = 62^\circ\,C$$

$$\Delta t'' = \sigma_2''/(E\alpha) = 1475/24 = 61^\circ\,C$$

Assuming, as Corini does, that the rail temperature can vary within the range -25° C and $+55^\circ$ C, we obtain the temperatures

$$t' = -25^\circ + 62^\circ = +37^\circ\,C$$

$$t'' = +55^\circ - 61^\circ = -6^\circ\,C$$

which limit the temperature range within which the rails must be assembled, in order that, when the limits -25° C and $+55^\circ$ C are reached, the thermal stresses shall not exceed the values σ_2' and σ_2'' already determined, based on a safe stress not exceeding 2400 kg/cm². This temperature range is quite ample to include the temperatures at which rails are usually laid in place. Thus, preheating to a certain temperature is superfluous within these limits.

Corresponding to the temperature rise of 61° C, the total compressive force for the two rails of the track will be

$$F = 2\,S\,\sigma_2'' = 2 \times 62{\cdot}48 \times 1475 = 181{,}192\text{ kg},$$

where $S = 62{\cdot}48$ cm² is the cross-sectional area of the 49 kg steel rail.

The concrete horizontal members must be sufficiently rigid to prevent deformations of the track. The resistance of these members to deflections of the track is, in fact, an elastic reaction, and, therefore, the equation of the distorted track axis will be of the type

$$EI\,\frac{d^4y}{dx^4} + F\,\frac{d^2y}{dx^2} + y = 0,$$

which applies both to the horizontal and the vertical plane.

By integrating this equation, we can determine the values of F for which there is no danger of lateral deflection. We obtain

$$F \leqq 2\sqrt{\beta EI} \quad .. \quad .. \quad (2)$$

and as F, E, and I, are known, β can be calculated so as to satisfy eq. (2); this gives

$$\beta \geq F^2/(4EI).$$

DISTORTION IN THE HORIZONTAL PLANE

The moment of inertia of the track with respect to the vertical axis passing through the centre of gravity is given by

$$I = 2\,S\,(s/2)^2 = 2 \times 62 \times 75^2 = 7{\cdot}0 \times 10^5\text{ cm}^4.$$

This formula assumes that the two rails are rigidly interconnected, and this assumption is a sufficiently close approximation to conditions occurring in practice, since the indirect clamping arrangement prevents relative rotation between the rails and the sleepers. Therefore

$\beta = 328 \times 10^{-3}/(4 \times 7 \times 2) = 0{\cdot}006$ kg/cm per cm,

or $\beta = 0{\cdot}6$ kg/m of rail and per cm displacement. We assume, as Corini does, a safety factor of 10, so that we have

$$\beta = 6 \text{ kg/m per cm displacement} \quad .. \quad (3)$$

To establish whether the tracks are suitable for the purpose previously defined, it will be sufficient to show that their maximum deflection is less than one centimetre for a horizontal load of 6 kg per metre. For this, and making a conservative assumption to simplify the calculation, we will regard the sleepers as being simply supported at their extremities, and that the area effectively resisting the couple is a rectangle of 15 × 40 cm². The maximum displacement is

$$\delta_1 = 5\,Q\,l^3/(384 \times EI) =$$

$$= 5 \times 30 \times 12{\cdot}5 \times 10^6/(384 \times 1{\cdot}5 \times 10^5 \times 1{\cdot}125 \times 10^4) = 0{\cdot}0287 \text{ cm.}$$

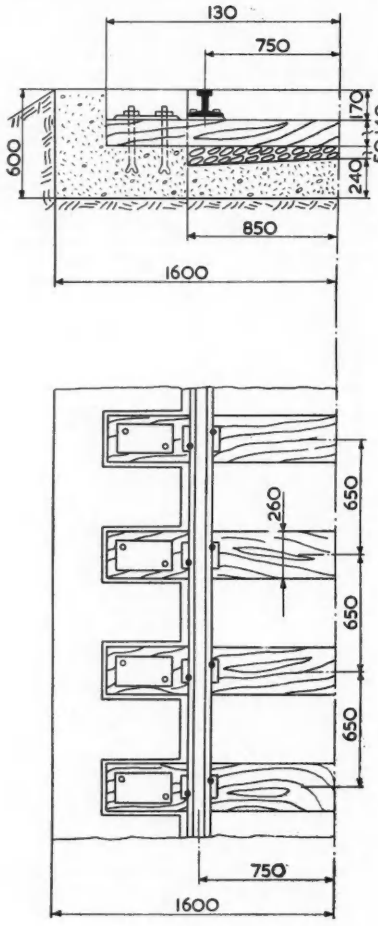


Fig. 1.

Therefore, the deflection of the vertical arms of the supports is

$$\delta_2 = 30 \times 2{\cdot}4 \times 10^5/(3 \times 1{\cdot}5 \times 10^5 \times 5{\cdot}1 \times 10^4) = 0{\cdot}0003 \text{ cm.}$$

Consequently,

$$\delta = \delta_1 + \delta_2 = 0{\cdot}029 \text{ cm}$$

and this gives

$$\beta = 6/0{\cdot}029 = 207 \text{ kg/m per cm} \quad .. \quad (4)$$

Thus, the margin of safety resulting from the comparison of eqs. (3) and (4) is ample.

DEFORMATION IN THE VERTICAL PLANE

Sagging of the Track

In this case also, the deformation of the track is resisted by a reaction of the ballast which is elastic in its behaviour, so that the 4-th order differential equation already given again applies, as is the inequality $F \leq \sqrt{\beta EI}$.

The moment of inertia of the track with respect to the horizontal axis is

$$I = 2 \times 1797 = 3594 \text{ cm}^4,$$

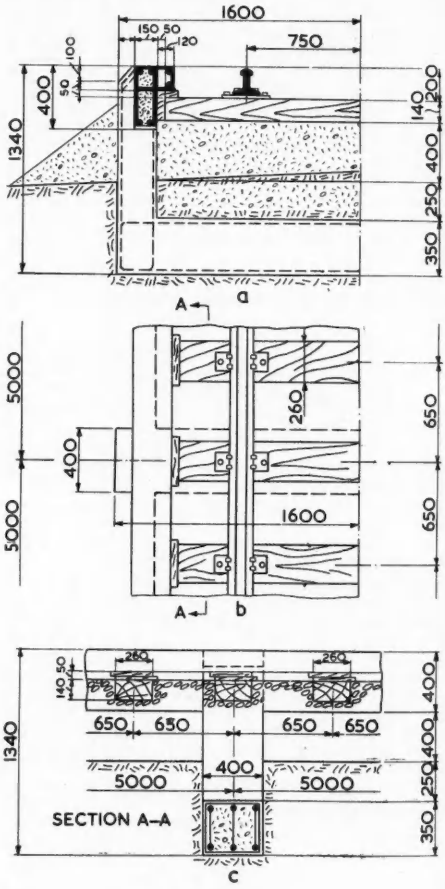


Fig. 2.

(a) Cross-section of track ; (b) Plan view of track ; (c) Side elevation (Section through A-A).

and, therefore,

$$\beta \geq 328/(4 \times 2 \times 3594) \times 10^2 = 1{\cdot}125 \text{ kg/cm per cm,}$$

or $\beta \geq 112{\cdot}50$ kg/m per cm deflection, and assuming a safety factor of 10:

$$\beta \geq 1125 \text{ kg/m per cm deflection.}$$

As we stated that the ballast would have a Winkler coefficient at least equal to 10 kg/cm² per cm, which is equivalent to

$$10 \times 100 \times 260 = 2{\cdot}6 \times 10^5 \text{ kg/m per cm},$$

this latter condition is amply fulfilled.

Lifting of Track

Disregarding the effect of the weight of the track which resists any tendency to lift and which is not significant, it will be sufficient to verify whether the arrangement with the two concrete horizontal members satisfies the condition 6 kg/m per cm. For this system, we have

$$I = 2 \times 15 \times 40^3/12 = 1{\cdot}6 \times 10^5 \text{ cm}^4,$$

and, therefore, the deflection, calculated as in the case of deformations in the horizontal plane, is

$$\delta = 5 \times 5{\cdot}625 \times 10^3 \times 12{\cdot}5 \times 10^7/(1{\cdot}5 \times 10^5 \times 1{\cdot}6 \times 10^5 \times 384) = 0{\cdot}381 \text{ cm},$$

and, therefore,

$$\beta = 5620/0{\cdot}381 = 14676 \text{ kg/m per cm displacement.}$$

The required condition is thus amply satisfied. In conclusion, it can be said that the structure which has been investigated would permit of using a jointless track, provided the temperature is between — 6° C and + 37° C when the rails are laid. A similar study of the track in Fig. 1 gives such a high rigidity that one can assume $\beta = \infty$ in practice. The project of Fig. 2 can easily be modified for curved tracks.

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RUSSIA

Economy of Alcohol in the Production of Insulating Materials

By S. V. QUASHNIN. (From *Vestnik Electro-Promyshlennosti*, No. 9, 1948, pp. 15-18, 1 illustration.)

THE Khotkov Insulating Materials Factory has been putting into effect a series of improvements in the manufacture of pressed laminated electrical insulating materials (Getinax, Textolit), varnished cotton and silk fabrics. At the same time, efforts were made to develop and introduce new kinds of electrical insulation, mainly with the object of reducing or completely avoiding the use of alcohol in the solution of bakelite resin.

It is known that ethyl alcohol is being used as a solvent for the resin during the bakelizing process when paper or fabrics are passed through the varnishing and drying machines, and that this alcohol is being evaporated and, therefore, lost. The amount of alcohol which is irretrievably lost in this way is considerable. The efforts of the "Isolit" factory to impregnate paper for Getinax with melted bakelite resin did not succeed in achieving the required specifications, and work in this direction had to be abandoned.

Other factories attempted to use so-called water emulsions and water solvents for bakelite resins on a phenol and cresole base, but these methods were also unsuccessful because the presence of an alkaline catalyst adversely affects the quality of the material obtained. In addition, the paper suffered due to the moisture and could not stand up to the mechanical stresses during the bakelizing process.

To decrease the waste of ethyl alcohol, the recovery method is being widely used. This method, however, in spite of the very complex and costly plant which it involves, does not recover the alcohol in its entirety. The waste still amounts to about 200 kg per ton of Getinax, apart from the increased steam consumption of the order of 30-40 per cent, the doubled expenditure on electric current, and the additional demand for water amounting to about 55 m³ per ton of the finished product. The Khotkov factory, therefore, tried to achieve a sharp reduction in alcohol by using varnishes of higher concentration than the 25-30 per cent concentrations hitherto employed. The aim was to use varnish of greater density and better adhesive properties so as to ensure the necessary impregnation and a certain percentage of resin content. A greater

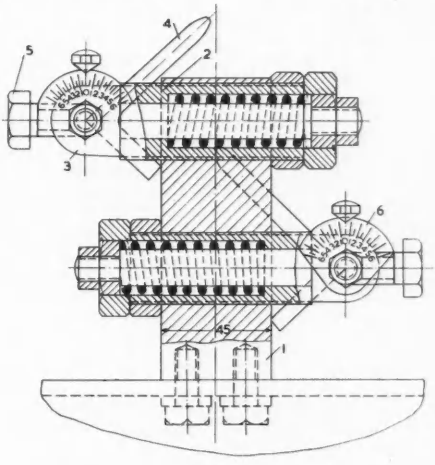


Fig. 1.

amount of resin inevitably had to be used, because the excess varnish could not be made to run off to the containers. Special squeezing plant was, therefore, developed and introduced to remove the excess varnish from the paper or fabric.

These arrangements (see Fig. 1) comprise knives (4) which are 1950 mm in length and made of 75 × 75 × 6 mm structural steel. The knives are adjustable in special supports (1) fixed to the frame of the impregnating machine above the varnish containers. Each support has two bores where the regulating bushes (2) and the regulating spring carrier (3) are located. The screw (5) adjusts both knives to the required position and angle. The edges of both knives are carefully rounded off. The construction allows of regulating

the position of the knives relative to the surface of the paper as well as the degree of pressure on the paper by setting the graduated sector (6). The arrangement provides for a suitable cover of varnish and the removal of excess varnish straight into the container, if the knives are properly adjusted and the radius of the edges is correct. The latter determines the amount of covering varnish.

It was experimentally established that 12 μ paper could be impregnated with bakelite varnish of 60-65 per cent concentration, resulting in less than one quarter consumption of ethyl alcohol. This method could be introduced without necessitating any changes in the other equipment and by maintaining the process as it was before.

The adoption of the method of impregnating paper and fabrics with bakelite varnishes of greater viscosity with only a small content of alcohol played a decisive part in solving the more far-reaching problem of completely eliminating the use of alcohol and replacing it by non-alcoholic liquid bakelite resins.

After comprehensive experiments both in the laboratory and under production conditions, a certain relation between the structure and viscosity of the resins obtained, the temperature during the condensation process, and the changes relating to the introduced components—formalin and phenol (or cresol, xylenol)—was established. As a result of these investigations, it was found possible to obtain quite a number of non-alcoholic liquid bakelite resins which were comparable in viscosity to alcoholic resins of 60-65 per cent concentration. The resulting resins have sufficient stability and, in their most important characteristics (period of polymerization, amount of volatiles, percentage of free phenols), fully conform to requirements. Vacuum drying of the resin by-products, the so-called over-resinous waters, is superfluous. These are separated by deposition in the settling tank or by a centrifugal process, thus shortening the whole process by one half or more and considerably increasing the number of cycles of resin boiling. For the time being, three types of non-alcoholic liquid bakelite resins were developed and are being applied: (a) resins of medium viscosity for the impregnation of 12 μ Getinax paper; (b) resins of lower viscosity as surface varnish for papers, and (c) resins of higher viscosity for the impregnation of fabrics for Textolit.

Five million roubles' worth of alcohol were saved in only six months during 1947. The current consumption was reduced from 290 kWh to 30 kWh per ton of resin, steam consumption being reduced from 1·2 to 0·2 tons per ton of resin. The previous special precautions against fire or explosion and special buildings necessary for safety reasons could be dispensed with. Needless to say, the costly plant for alcohol recovery and its accommodation became superfluous.

The over-resinous waters and their content of formalin and phenol were previously wasted and polluted the vicinity. The abolition of vacuum drying made possible the utilization of these by-products because the deposits can be boiled again in the bakelite vessel after adding the necessary catalyst. The technology of this boiling process, although specifically different, is not attended with any special difficulties and enables a rational utilization of the phenol and formalin which were previously wasted together with the over-resinous waters.

GERMANY

Adhesion Strength of Electrolytic Deposits

By R. ERDMANN. (From *Metalloberfläche*, Vol. 2, No. 5/6, May/June, 1948, pp. 117-119.)

BAD adhesion can usually be traced to faulty preparation of the parent plate or deposited material, such as e.g., insufficient degreasing, descaling or rinsing, or to imprints caused by perspiring hands, and sometimes to hydrogen absorption or colloidal precipitations. Alloy formation between the plate and deposit improves adhesion, but is only possible at room temperature in special cases, for instance, in Cu-plating of zinc. The tendency towards alloy formation can be increased, however, by subsequent heating. Slight roughening of the parent plate will only result in an improvement of adhesion if the grooves are completely free of oxides, grease, air bubbles, dust and non-metallic particles, for it is only in this event that the deposit can be anchored in the grooves.

Different *steels* and different methods of manufacture of steel require different electrolytic conditions and influence the adhesion qualities of deposits. Cold rolling gives a smooth surface and fine grain structure particularly suitable for bright nickel deposits. Hard surfaces or surfaces which are heavily ground or polished have greater affinity for hydrogen and cause unfavourable perpendicular growth of the deposited crystals. Pickling cannot remove the thin hard surface layer, but only attacks grain boundaries, thus roughening the surface, and may produce unfavourable amorphous segregations by dissolution of carbides. Under certain conditions, anodic preparation has proved most effective, since it dissolves the steel uniformly, creates microscopically smooth surfaces the ferrite crystals of which are free to influence the crystalline structure of the deposit. Electrolytes for anodic preparation have a basis of sulphuric acid with additions of other acids in order to keep the anodic parent plate in a passive condition and, thus, produce a clean and metallographically ideal plating surface. With a current density of 225 amp. per sq. ft. the preparation takes 1 to 2 minutes. Rolling scale can be removed, if necessary, by means of frequent pole reversal. Hydrochloric acid baths are used for surface roughening. Acids must not, however, be transferred to the plating bath. Electrolytic degreasing frequently follows anodic preparation. Cathodic preparation with lead anodes is also used, the lead deposit being removed in an alkaline bath. A patented process for nickel plating of stainless steel uses anodic preparation and, after pole reversal, plates in the same bath containing Ni-chloride and hydrochloric acid.

Cast Iron which is to be plated should show a uniformly fine distribution of graphite, and should be pickled and then electrolytically degreased, and loose graphite particles should be scraped off. A first layer of Cu-deposit is recommended, since copper covers graphite segregations better than does, e.g., nickel.

Plating on *non-ferrous metals* often introduces differential thermal expansion. Where the coefficients of thermal expansion of surface and deposit are very different, an intermediate layer of a metal with a mean coefficient may be advantageous. *Brass* surfaces are easily damaged by grinding, so that the deposit does not adhere in the grooves. Polishing, however, does not cold-harden brass surfaces, because of the action of the polishing acids. Good adhesion can be obtained, without further preparation, on brightly polished brass surfaces. Anodic preparation in a weak alkaline bath with subsequent removal of the anodic oxide film in a nickel bath (which, after pole reversal, may be used as a plating bath) further improves adhesion. Anodic roughening of the brass surface can be obtained in a cyanide or weakly acidic bath in 30 seconds with 40

amp. per sq. ft. Cu-plating on *copper* sheet led to the discovery that bad adhesion may be caused by a colloidal film of proteins or their decomposition products. These films also strongly adhere to copper, steel, nickel, etc. *Zinc* is easily soluble in electrolytic baths, and if a plating layer is started by ion exchange, without current, the subsequent deposit will not adhere. Zinc is, therefore, often Cu-plated first. Die-cast zinc alloys are difficult to plate unless the copper content is very low. *Lead* forms oxide films very speedily. Removal of oxide layers in dissolved nitric acid and subsequent Cu-plating in a cyanide bath are recommended. Lead deposits do not adhere properly to steel, and a copper layer is often deposited first. *Tin* can be treated similarly to zinc, with lower current densities. *Aluminium* and Al-alloys should not be plated, if this is avoidable, since a porous plating does not keep out humidity and accelerates electrolytic destruction. If plating is needed, the surface should be slightly roughened by special nickel-chloride or ferro-chloride pickling.

ITALY

New Trolley-Bus Types

(From *Tecnica Italiana*, Vol. 3, No. 4, July-August, 1948, pp. 211-215, 9 illustrations.)

THE Società Alfa Romeo, of Milan, is producing, mainly for export, new trolley-buses with an unusually large loading capacity, as well as other similar, large and medium-size vehicles.

The trolley-bus type 110 AFS/5 is a five-axle vehicle 63-ft 5½-in in length, designed for heavy city traffic. It consists of two articulated sections permanently joined together (see Fig. 1.) The first section has one axle with steering wheels and two axles with driving wheels, while the second section has two axles with steering wheels. The articulated system connecting the two sections permits relative angular motion to take place in the horizontal and vertical planes, and the complete system can take curves with a radius equal to that which would be described by the first section alone.

The trolley-bus is fitted with three types of mechanical and pneumatic brakes. The standard foot brake, giving a high-speed adjustable braking effect, acts on all 10 wheels simultaneously by means of distributor valves fed from auxiliary tanks. The auxiliary hand brake acts on all axles except the first, and is manually operated by the driver in the event of a breakdown occurring in the pneumatic system. The emergency brake acts mechanically on the two driving axles with a double-acting bell crank lever, and pneumatically on the other two rear axles, and incorporates electro-pneumatic controls. The brakes can also be arranged to operate automatically if, owing to a manœuvring error in reverse operation, the angle between the two elements exceeds a certain critical value.

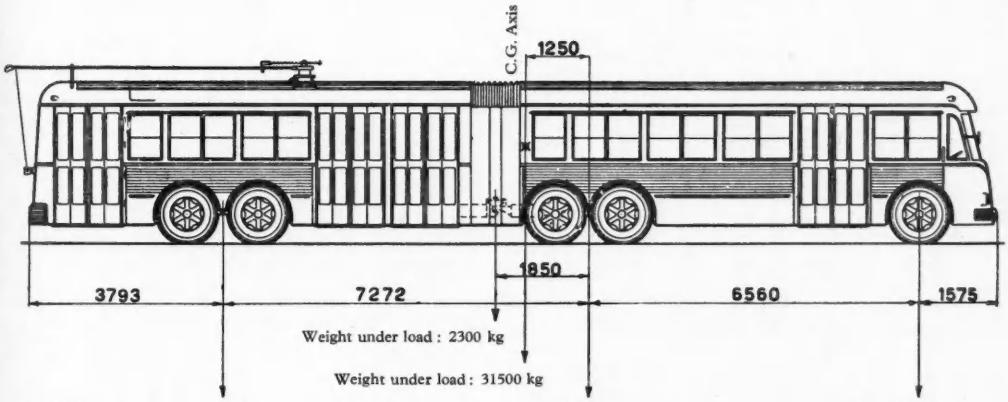
The trolley-bus is driven by an Italian Brown-Boveri motor with an economical speed range from 24 to 15-25 mph in built-up areas, 20-31·3 mph in suburban districts.

The body, built by Macchi S.A. of Varese* can accommodate 210 passengers. The trolley-bus is served by two conductors during peak hours, and one conductor at other periods, one or two entrance doors being used.

A number of other articulated trolley-buses also being built by Alfa Romeo are of the four-axle type 110 AFS/4, 55-ft 5-in long, accommodating 160 passengers, served by one conductor only. The vehicle is powered by a 200 hp Marelli motor. Four-axle trolley-buses are also being built at the Alfa Romeo works for Stockholms Spärväger (Stockholm Transport).

Three-axle buses of the 110 AFP type with a single element body are being manufactured with the co-operation of Piaggio and Ansaldo for the coachwork and the electrical equipment. The coachwork is of stainless steel and can, therefore, be used without an inside or outside paint coating. In this type of trolley-bus the track width is increased from 5·90 to 6·60 m (from 19-ft 4-in to 21-ft 8-in), and, in order to obtain a small radius of rotation, the maximum angular deflection of the steering wheels has been increased. Alfa Romeo is also building small-size trolley-buses type 430 AF with sitting and standing accommodation for 55 passengers, for small and medium size towns.

* Previously known as manufacturers of high-speed seaplanes.



Weight empty :	6720 kg	7710 kg	4550 kg
Weight fully laden :	12855 kg	12590 kg	6055 kg

Fig. 1. **Alfa-Romeo Trolley-bus, type 110 AFS/5, showing load distribution over the five axles. (Dimensions in mm).**

Boundary Flow in the Diffuser of a High-Pressure Boiler Feed Pump

By J. J. HOLBA. (From *Maschinenbau und Wärmewirtschaft*, Vol. 3, No. 11, November, 1948, pp. 165-169, 7 illustrations.)

ON dismantling a boiler feed pump, it was found that the streamlines of the boundary flow in the diffuser had been made visible by corrosion. Erosion had also occurred at regular distances from the leading edges of the diffuser vanes.

In order to interpret these phenomena, and to find their causes, extensive quotations will be made from references.[1–5]

PREVIOUS EXPERIMENTAL INVESTIGATIONS

It has been shown experimentally[1] that the turbulence in the transition zone between impeller outlet and diffuser inlet of a centrifugal pump is caused by boundary phenomena near the walls of the diffuser ring. It is known that some of the water pumped out of the impeller returns to it, and is given a further impulse. In consequence, there is a higher energy content, and hence a higher pressure, at the diffuser inlet than is predicted on the assumption of streamline flow, and the action of the impeller has to be subjected to further analysis.

Let us consider the flow of water leaving the impeller. Internal friction will slow down the boundary flow relative to the main flow, and the energy of the boundary layer will become insufficient to overcome the pressure gradient which exists in the diffuser passage. There will thus be a return flow to the impeller, the relative motion of which is shown in Fig. 2. The width of the turbulent zone is dependent on the rate of pumping. (If the design capacity is called Q_D, and the actual rate of pumping is Q, then Q/Q_D is the factor governing this phenomena.) For $Q/Q_D = 0$, the head is so large that no water passes through the diffuser and the whole passage is filled with a double vortex, as shown in Fig. 2a, which consumes the entire energy input. For rates of flow $0 < Q < Q_D$, Fig. 2b gives an indication of the secondary flow pattern. The energy used by this turbulence has, of course, to be supplied from the shaft. In the experiments[1], the boundary flow pattern was observed by painting the diffuser and running the pump with a constant ratio Q/Q_D while the paint was still plastic, so that the streamlines were imprinted on the paint. The results of two such runs are shown in Fig. 3, from which it is clear that the secondary flow occurs at full as well as partial load.

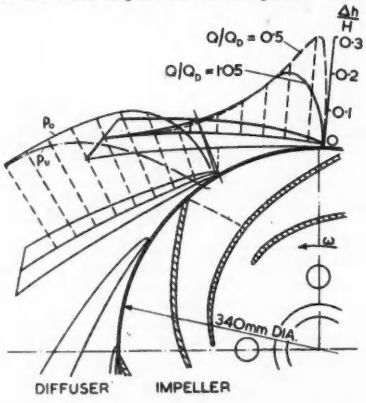


Fig. 1. **Pressure distribution on diffuser vanes of a centrifugal pump, according to H. Schrader.**
$\Delta h/H$ = Pressure drop across vane/impeller pumping pressure.
p_o, p_u = Absolute pressures at top and bottom of vanes, respectively.
Q = Actual rate of pumping, Q_D = Designed rate of pumping.

At the same time, the pressure distribution on the diffuser vanes was measured, as shown in Fig. 1. On the topmost vane, the pressure difference across the vane is shown as a fraction of the head developed by one stage, and it is seen to have its maximum near the leading edge of the vane. The pressure difference is larger for partial load than full load, as would be expected from Fig. 2. On the second vane, the absolute

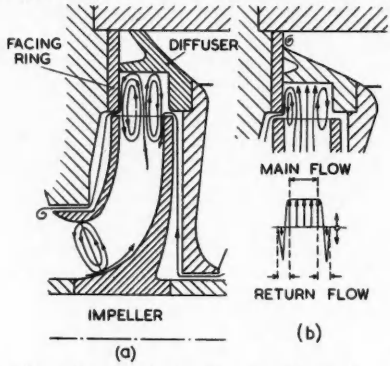


Fig. 2. **Secondary flow in impeller and diffuser of a centrifugal pump.**
(a) Rate of pumping, $Q = 0$.
(b) Pumping at partial load, $0 < Q < Q_D$.

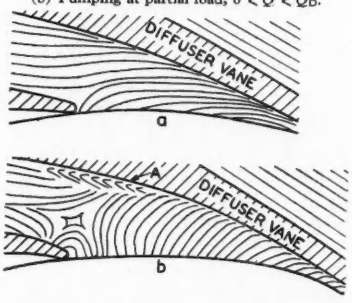


Fig. 3. **Streamlines of boundary flow in the diffuser of a centrifugal pump, according to Schrader.**
(a) for $Q/Q_D = 1$. (b) for $Q/Q_D^2 = 0{\cdot}4$.

pressures at full load have been indicated. At the top of the vane, maximum pressure occurs very near the leading edge, but also on the underside, this value is nearly reached at the entry of the passage proper. It follows that, contrary to the predictions on the assumption of non-rotational flow, the pressure rise in the diffuser occurs mainly at the diffuser inlet, while the pressure increase expected in the diffuser passage is not substantiated. The cause of this is the effect of the secondary flow previously mentioned: for, while in straight pipe flow an exchange of impulse is brought about by transverse mixing of boundary layer and main flow, this function is taken over by the secondary flow at the diffuser inlet, causing a higher pressure there than would normally be expected. On the other hand, the superposition of the secondary on the normal flow gives rise to a very irregular distribution of velocities

at the entry of the passage, and further pressure rise is largely prevented until this equalises, and is thus only partly achieved. Similar results on pressure rises in diffuser ports are reported[2]. Further corroboration comes from work by Lalive[3], who measured the pressures in the diffuser by a piezo-crystal, amplified and recorded on an oscillograph. A pressure rise of about 85 psi out of the total of 340 psi occurred in the channel, the remainder taking place at the diffuser inlet.

OBSERVATIONS MADE ON A FEED PUMP

(1500 hp, 2900 rpm, 5 stages, 1300 psi delivery pressure)

These results were confirmed by the following observations, directly in the case of the boundary layer streamlines, and indirectly as regards the pressure differences across the diffuser vanes. It may be pointed out that boiler feed pumps rarely work at maximum efficiency; safety considerations require ample reserves of capacity. In the present case, the pump operated at $Q/Q_{a\ max}$ between 0·6 and 0·7.

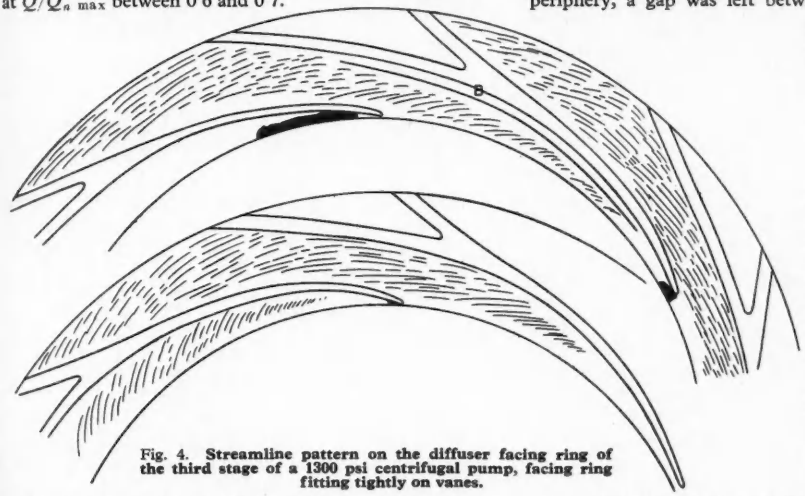


Fig. 4. **Streamline pattern on the diffuser facing ring of the third stage of a 1300 psi centrifugal pump, facing ring fitting tightly on vanes.**

The feed water had a pH value of 6·2 to 7·8 at 23° C. At a pump temperature of 175° C, a pH value of 5 to 6·5 may thus be expected, and corrosion is then quite severe on cast steel as well as cast iron. On cast steel, a flaky, dark grey corrosion product was found, while cast iron was covered by a thick, black layer. A prolonged spell of disuse had, furthermore, caused rusting of all the pump passages.

Careful scraping of these surface coatings on the diffuser facing rings revealed a clear black map of the streamline pattern against the background of rust on the unscraped valleys. As no photographic equipment was at hand, tracings were prepared and reproductions of the patterns can be seen in Figs. 4 and 5. Later, it was found that even after complete removal of all corrosion scale, the streamlines stood out in relief on the metal of the facing rings.

The diffusers in this pump are made according to established practice, being divided in a plane perpendicular to the shaft (Fig. 2). The facing ring is fastened to the main casting of the diffuser by two screws. The requirement of pressure-tight fitting of the facing ring has not been met in practice, as it seems to demand uneconomically close tolerances. Thus, in this case, only about a third of the periphery of the cover fitted tightly on to the vanes, while over the remainder of the periphery, a gap was left between the vanes and the plate. The result was two distinct streamline patterns with characteristic erosions.

DISCUSSION OF THE STREAMLINE PATTERNS

Fig. 4 shows the patterns found with a tightly fitting facing ring. Just below the leading edge of the vane there is a small set of erosions caused by cavitation at partial load. Otherwise, the conformity between Fig. 4 and some condition between Figs. 3a and 3b is obvious, down to the spiral vortices at A (Fig. 3b) and B (Fig. 4, top). Immediately after entry, the secondary flow pattern is deflected substantially into the direction of the passage. There is now, however, some energy exchange between the boundary layer and the main stream, as may be judged from the slightly eddying and turbulent flow in the passage. This would be similar in effect to the energy exchange in normal pipe flow. Near the cylindrical boundary of the diffuser there is a further vortex, as the secondary flow is damped when the main flow changes into a flow in an axial direction; this is also indicated at the top of Fig. 2b.

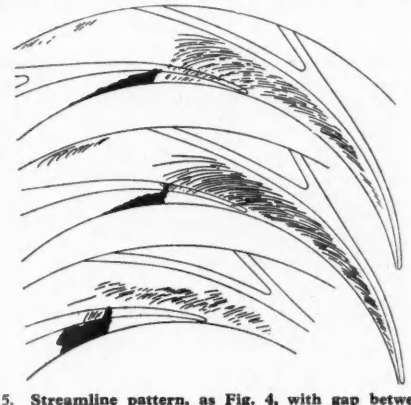


Fig. 5. **Streamline pattern, as Fig. 4, with gap between, facing ring and vanes.**
(Black areas—erosion cavities).

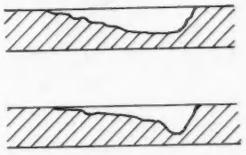


Fig. 6. **Peripheral section through the erosion cavities shown in Fig. 5.**

A different pattern is exhibited by flow in the presence of a gap and the partial flow through it (Fig. 5). Here, both by the secondary flow and by the large pressure difference across the vane, a partial return flow of very high velocity is indicated by the downward

direction of the streamlines over part of the top of the next diffuser passage, and by the substantial erosion in which it terminates. Beyond this erosion, the pattern is similar to that of Fig. 4.

CAUSES OF THE EROSIONS

From the location of the erosions in the streamline pattern, the importance of the partial return flow in this connection is obvious. That we are dealing with substantial flows is indicated by Fig. 6, which shows peripheral sections through two of the cavities, of a depth of 5 mm and a length of about 50 mm. The surfaces are smooth, as would be expected with cavitation erosion. The cause of cavitation may be imagined to be as follows (bearing in mind that the pumping temperature is high). There are great differences in the direction and velocity of the partial return flow on which it impinges. It is likely that free interfaces are formed, at which the friction and energy release are high[5]. If the resulting rate of increase of heat is higher than the rate of dissipation, a steam pocket will be formed. Carried further along, heat dissipation would prevail over the vapour pocket, which would consequently collapse. If this collapse were to take place near the surface of the facing ring, cavitation erosion would result. The corrosion mechanism is the same, whether it originates from the cycle pressure drop—pressure rise, or the heating-cooling cycle, as the cause of corrosion is, in any case, the collapse of vapour pockets. A combination of both cycles can also take place.

The erosion effects were in this case, of course, reinforced by the acidity of the feed-water. The observed cavities may, therefore, be regarded as being within the range made feasible by this explanation.

CONCLUSION

It was observed that, similarly to Fig. 4, only minor slipstream erosion took place near the cast roots of the vanes, the remainder of the diffuser passages being free from erosion. It would, therefore, seem right to manufacture diffusers from one integral casting, especially as this would be quite feasible in view of the large accessible surfaces involved. The somewhat higher expense should be justified by the avoidance of the type of erosion described herein.

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CANADA

Fatigue Tests of Spot Welds: Improvement of their Endurance Limit by Hydrostatic Pressure

By G. WELTER. (From *The Welding Journal Research Supplement*, June, 1948, 14 pages, 24 illustrations.)

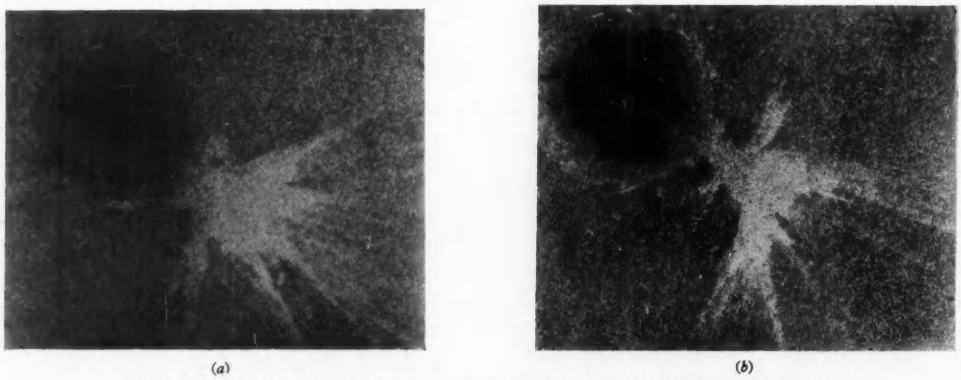
(Concluded from March issue.)

VI. TEST RESULTS

X-Ray Investigation.

From the beginning of this investigation it was recognized that an accurate non-destructive X-ray examination of the welded spots would be of great help in indicating the quality and strength properties of the joints which were very irregular. By taking a radiograph of every spot a selection between fairly sound and faulty specimens was possible, having on record an accurate survey of the possible internal defects of the welds. The non-destructive X-ray investigation was of specially great importance for the planned fatigue tests of the destructive type, as presence and extent of cracks, porosity, shape and size of the weld zone as well as holes or other major defects of the spots could be traced before the specimens were submitted to the long-time fatigue tests.

In some of the radiographs of the 24ST Alclad specimens, manufactured for these fatigue tests under special optimum working conditions, under a magnification of the spot (about $^{5}/_{16}$-in dia.), important faults became clearly visible as may be seen by Fig. 4 (a–b), representing some characteristic defective spots



(*a*) (*b*)

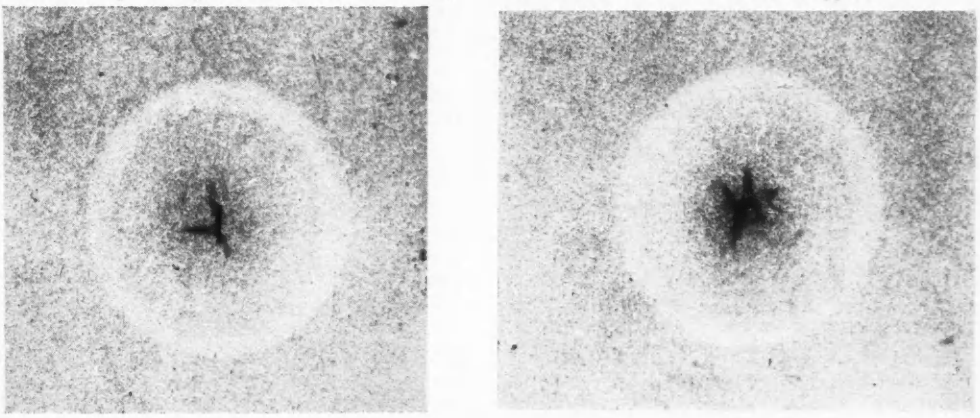
Fig. 4 (*a–b*). **Radiographs of some specimens of 24ST alclad 0·064 in thickness sheets, × 3.**

under a magnification of about 3 ×. Very heavy edge expulsion outside of the spot or cracks in the middle of the nugget of varying detrimental degree as shown in Fig. 5 (a) or very pronounced holes sometimes surrounded by smaller cracks as shown in Fig. 5 (b), could easily be detected without testing or using any destructive method on the specimens. On the other hand, this method reveals only crude and pronounced faults in the spots. It gives no information, for instance, on welds showing metallurgically insufficiently welded spots or oxide film between spots, longitudinal cracks, segregation of the cast metal in the nugget, unequal penetration, small Alclad inclusions, coarse crystals, transcrystallization, layered structure, etc.; all these defects, mostly not visible in the X-ray film, cause fairly low mechanical properties of the welds, especially under fatigue loads.

Mild Steel and Stainless Steel (18-8).—In spot welding these samples practically no special difficulties were encountered in the factory.

Metallographic Investigations of Spot-Welded Specimens

To confirm the above X-ray results of the spot-welded samples a certain number of specimens, which the radiographs showed to be sound, were analysed with regard to their micro- and macro-structures. Sections were taken of the specimens in a transverse direction, that is, in a plane vertical to the surfaces of the welded sheets, showing the profile of the spot and its principal characteristic zones. In a few specimens also the welded nugget itself, in a plane situated between the sheets, was examined with regard to its microscopic and macroscopic structures. The principal faults encountered in the structure of the nugget made visible by etching, are holes, voids, cavities, cracks and other irregularities. The sections of specimens treated by hydrostatic pressure compared with untreated spots are also made visible in this way.



(*a*) (*b*)

Fig. 5 (*a–b*).—**Defects of single spots.**

Mechanical Test Results.

Fatigue under Zero to Tension Tests.—The results of the fatigue tests under repeated loads of zero to tension, varying between 300 lb as a minimum and a maximum load of about 650 lb, are plotted in the original article. These results are represented statistically, one figure giving the results of investigations carried out on the first pulsator, the other figure those on the second pulsator.

The number of cycles varied between 2,000,000 and 4,000,000. On the first pulsator about 100 tests were made, on the second about 70 tests. Some specimens were untreated, others were mechanically treated, some were broken by cracking in the spot or the sheet around the weld; in one case an expulsion was visible in the broken specimen. Specimens which did not break at all were specially marked indicating that the repeated load could be continued without failure, but that the tests were stopped at a certain number of cycles.

Finally, specimens other than Alclad 24ST alloy such as mild and stainless steel were also tested and the results recorded.

In plotting the recorded fatigue values of untreated Alclad 24ST alloy specimens of 0·064-in thickness, together with other published results of fatigue tests of the same type (pulsating in tension) and the same material, the shadowed area of Fig. 6 may represent the fatigue loads of this material. All average values of sound welds for the various loads, as recorded during this investigation, fall within the boundaries of this area which may be considered as average possible fatigue values of sound spot-welded Alclad 24ST alloys of 0·064-in thickness under pulsating loads (minimum to maximum tension), scattering, as generally known, over a fairly wide range. At more than 10,000,000 cycles, a load of about 200 lb per spot may be regarded as a good average value for this material. Comparing this fatigue value of untreated specimens in received condition with that of specimens mechanically treated under hydrostatic loads, a greater number of the latter specimens withstood 550 lb per spot without failure after several million cycles, and in one case even as high as 29,000,000 cycles. And at 650 lb per spot, from 4,000,000 to 10,000,000 cycles were applied without failure. This indicates that the fatigue limit at 10,000,000 cycles is higher than 650 lb per spot. The value of the endurance limit at higher loads (between 650 and 800 lb) may possibly be found as indicated in the shadowed upper area.

From these results the following temporary conclusion may be drawn: Because of the described hydrostatic treatment of the spots under very high local pressure, an improvement of about 250 to 300 per cent of spot-welded Alclad 24ST aluminium alloy sheets (0·064 in thickness) may be considered possible at a fatigue limit of 10,000,000 cycles. For a smaller number of cycles, say 1,000,000, this fairly high percentage of improvement decreases somewhat and is of the order of 200 to 250 per cent. This is true because the upper shaded area is less steep than the lower area; practically both areas join each other at half a cycle, that is, at the ultimate static shear load of the weld.

SUMMARY AND CONCLUSION

From the numerous fatigue tests carried out with specimens in the as-received condition as well as after

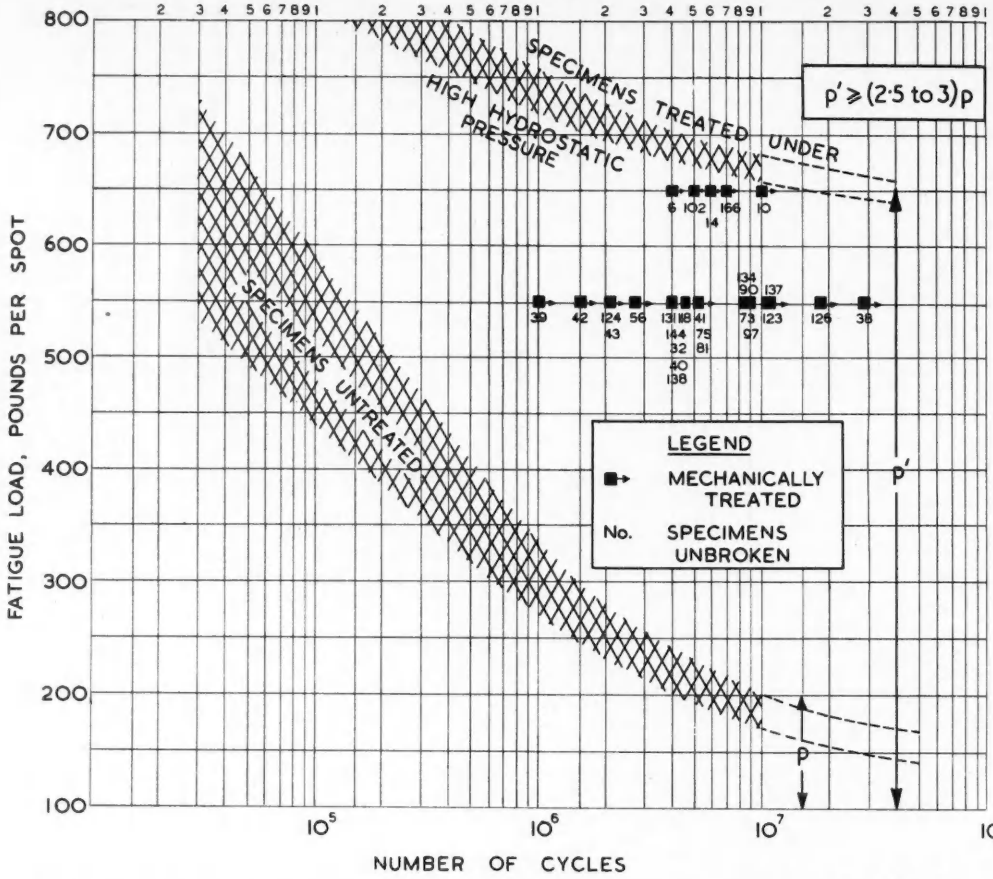


Fig. 6. **S.N. curve with fatigue test results of untreated and treated Alclad 24ST aluminium alloy specimens of 0·064-in thickness.**

having undergone hydrostatic pressure, it can be stated that an appreciable improvement of the fatigue properties has been recorded. These fatigue tests, as carried out on two different types of pulsators, are in fairly good accord, indicating that the fatigue load of mechanically treated specimens can be increased materially without sustaining failure of any welded Alclad 24ST aluminium alloy samples. Temporarily the following conclusions can be drawn: an improvement of about 250 to 300 per cent of treated spots compared to spots in the as-received condition seems possible.

These tests should, however, be extended to still higher fatigue loads as well as to a higher number of cycles, at least in a few cases, to determine the final endurance limit of these welds at over 10,000,000 to several hundred millions of cycles. Also a comparison of the improved spot welds with rivetted joints, as used in aircraft, would doubtless be of greatest interest to show the superiority of mechanically treated spot welds over rivetted joints. This could be easily done by checking regularly the transverse rigidity of the rivetted joints after a certain number of cycles, that is their static torsional resistance compared to spot welds. These joints will probably show up to be incomparably superior to rivetted joints which, as generally known, under repeated loading loosen up gradually but continue to carry load. Effects, such as recorded with hydrostatically compressed Alclad 24ST alloy sheets, have been found in mechanically treated stainless steel and mild steel specimens. Here, too, the limit values, neither of the fatigue load nor the number of cycles, could be finally determined, due chiefly to the low speed of the repeated tension fatigue machines and to the restricted number of machines available.

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The Dynamic Capacity of Rolling Bearings

By G. LUNDBERG and A. PALMGREN. (From *Acta Polytechnica*, Mechanical Engineering Series, Vol. 1, No. 3, Issue 7, 1947, 50 pages, 22 illustrations.)

(*Concluded from January issue.*)

(4) *Calculation Tables for Dynamic Basic Capacity.*

The basic dynamic capacity of bearings can be calculated by means of the formulae in Tables IV and V. Table IV is valid for ball bearings, and for roller bearings with line contact, i.e., for which eq. (30) gives $2a \geq 1{\cdot}5\, l_a$ for the major axis of the pressure ellipse. Table V is for roller bearings with point-and-line contact.

The notation used is: D_a = rolling diameter of the rolling body, d_m = pitch diameter, l_a = length of contact, l_r = length of rolling body, r_i, r_e = maximum groove radii, Z = number of rolling elements per row, α = contact angle, f_c = coefficient dependent on material and bearing type, i = number of active rows of rolling elements. Within the ordinary range of dimensions, the contact length l_a of the rolling element can be estimated for conventional roller bearings by

$$l_a = l_r - 1{\cdot}2\, l_r^{0{\cdot}4} \text{ [mm]} \quad .. \quad (85)$$

for bearings with grinding relief grooves in the bearing raceways, and by

$$l_a = 0{\cdot}9\, l_r \quad .. \quad .. \quad (86)$$

for bearings without relief and considering end radii. In certain bearing designs, for instance double-row spherical roller bearings with loose guide rings, a special calculation of l_a is required.

7. EQUIVALENT LOADS OF BEARINGS

For arbitrary conditions of load and rotation the bearing life L can be determined by means of the equation

$$L = (C/P)^3 \quad .. \quad .. \quad .. \quad (87)$$

where C = basic capacity of the bearing, and P = equivalent load. The equivalent radial and thrust loads of radial and thrust bearings will be denoted by P_r and P_a. The equivalent loads are the loads which, under the running conditions used in determining C,

TABLE IV. BASIC DYNAMIC CAPACITY OF BALL BEARINGS AND OF CONVENTIONAL ROLLER BEARINGS

Type	Point Contact of Ball Bearings			Line Contact of Roller Bearings		
C	$f_c f_a i^{0{\cdot}7} Z^{2/3} D_a^{1{\cdot}8}$			$f_c f_a i^{7/9} Z^{2/3} D_a^{29/27} l_{ai}^{7/9}$		
f_c	$g_c f_1 f_2 \left[\frac{2 r_i}{2 r_i - D_a}\right]^{0{\cdot}41}$			$g_c f_1 f_2$		
g_c	$\left[1 + \left(\frac{C_i}{C_e}\right)^{10/3}\right]^{-0{\cdot}3}$			$\left[1 + \left(\frac{C_i}{C_e}\right)^{9/2}\right]^{-2/9}$		
$\frac{C_i}{C_e}$	$f_3 \left[\frac{r_i}{r_e} \frac{2 r_e - D_a}{2 r_i - D_a}\right]^{0{\cdot}41}$			$f_3 \left[\frac{l_{ai}}{l_{ae}}\right]^{7/9}$		
Type	Radial Bearing	Thrust Bearing		Radial Bearing	Thrust Bearing	
		$\alpha \neq 90°$	$\alpha = 90°$		$\alpha \neq 90°$	$\alpha = 90°$
γ	$\frac{D_a \cos \alpha}{d_m}$		$\frac{D_a}{d_m}$	$\frac{D_a \cos \alpha}{d_m}$		$\frac{D_a}{d_m}$
f_a	$(\cos \alpha)^{0{\cdot}7}$	$(\cos \alpha)^{0{\cdot}7} \tan \alpha$	1	$(\cos \alpha)^{7/9}$	$(\cos \alpha)^{7/9} \tan \alpha$	1
f_1*	3·7 — 4·1	6 — 10		18 — 25	36 — 60	
f_2	$\frac{\gamma^{0{\cdot}3} (1-\gamma)^{1{\cdot}39}}{(1+\gamma)^{1/3}}$		$\gamma^{0{\cdot}3}$	$\frac{\gamma^{2/9} (1-\gamma)^{29/27}}{(1+\gamma)^{1/3}}$		$\gamma^{2/9}$
f_3	$1{\cdot}04 f_4$	f_4	1	$1{\cdot}14 f_4$	f_4	1
f_4	$\left[\frac{1-\gamma}{1+\gamma}\right]^{1{\cdot}72}$			$\left[\frac{1-\gamma}{1+\gamma}\right]^{38/27}$		

*Units in kg and mm

TABLE V. BASIC DYNAMIC CAPACITY FOR ROLLER BEARINGS WITH POINT-AND-LINE CONTACT.

$$C = C_i \left[1 + \left(\frac{C_i}{C_e} \right)^4 \right]^{1/4}$$

Bearing Type	Radial Bearing	Thrust Bearing		Radial Bearing	Thrust Bearing	
		$\alpha \neq 90°$	$\alpha = 90°$		$\alpha \neq 90°$	$\alpha = 90°$
	Inner ring			Outer ring		
γ	$\frac{D_a \cos \alpha}{d_m}$		$\frac{D_a}{d_m}$	$\frac{D_a \cos \alpha}{d_m}$		$\frac{D_a}{d_m}$
C_i	Line Contact C_i			Point Contact C_e		
C_e	$f_1 f_2 f_a i^{7/9} Z^{2/3} D_a^{29/27} l_{ai}^{7/9}$			$f_1 f_2 f_a \left[\frac{2R}{D_a} \frac{r_e}{r_e - R} \right]^{0.41} i^{0.7} Z^{2/3} D_a^{1.8}$		
f_a	$(\cos \alpha)^{7/9}$	$(\cos \alpha)^{7/9} \tan \alpha$	1	$(\cos \alpha)^{0.7}$	$(\cos \alpha)^{0.7} \tan \alpha$	1
f_1*	18 — 25	36 — 60		3·5 — 3·9	6 — 10	
f_2	$\frac{\gamma^{2/9} (1 - \gamma)^{29/27}}{(1 + \gamma)^{1/3}}$		$\gamma^{2/9}$	$\frac{\gamma^{0.3} (1 + \gamma)^{1.39}}{(1 - \gamma)^{1/3}}$		$\gamma^{0.3}$
C_i	Point Contact C_i			Line Contact C_e		
C_e	$f_1 f_2 f_a \left[\frac{2R}{D_a} \frac{r_i}{r_i - R} \right]^{0.41} i^{0.7} Z^{2/3} D_a^{1.8}$			$f_1 f_2 f_a i^{7/9} Z^{2/3} D_a^{29/27} l_{ae}^{7/9}$		
f_a	$(\cos \alpha)^{0.7}$	$(\cos \alpha)^{0.7} \tan \alpha$	1	$(\cos \alpha)^{7/9}$	$(\cos \alpha)^{7/9} \tan \alpha$	1
f_1*	3·7 — 4·1	6 — 10		15 — 22	36 — 60	
f_2	$\frac{\gamma^{0.3} (1 - \gamma)^{1.39}}{(1 + \gamma)^{1/3}}$		$\gamma^{0.3}$	$\frac{\gamma^{2/9} (1 + \gamma)^{29/27}}{(1 - \gamma)^{1/3}}$		$\gamma^{2/9}$

*Units in kg and mm

give fatigue values equivalent to those of the actual load F.

(1) *Single-Row Bearings*

If the indices 1 and 2 are assigned to the ring which rotates relatively to the direction of the load, and the stationary ring, respectively, then the mean values of the rolling body load are obtained from eqs. (65) and (69) :

$$Q_{c1} = Q_{\max} \mathcal{J}_1 = F_r \mathcal{J}_1 / (Z \cos \alpha \mathcal{J}_r) = F_a \mathcal{J}_1 / (Z \sin \alpha \mathcal{J}_a) \quad (88)$$

$$Q_{c2} = Q_{\max} \mathcal{J}_2 = F_r \mathcal{J}_2 / (Z \cos \alpha \mathcal{J}_r) = F_a \mathcal{J}_2 / (Z \sin \alpha \mathcal{J}_a) \quad (89)$$

where F_a and F_r are the thrust and radial load components. If

$$\mathcal{J}(t\,;\,s) = \left[\frac{1}{2\pi} \int_{-\psi_0}^{+\psi_0} d\psi \left[1 - \frac{1}{2\epsilon} (1 - \cos \psi) \right]^t \right]^{1/s} \quad (90)$$

then for *point* contact $\mathcal{J}_1 = \mathcal{J}_1(\epsilon) = \mathcal{J}(9/2\,;\,3)$, and $\mathcal{J}_2 = \mathcal{J}_2(\epsilon) = \mathcal{J}(5\,;\,10/3)$; and for *line* contact $\mathcal{J}_1 = \mathcal{J}(3\,;\,3)$, and $\mathcal{J}_2 = \mathcal{J}(9/2\,;\,9/2)$. In eq. (90) ψ is the angle coordinate measured from the most heavily loaded rolling body, and s and t are auxiliary quantities, while ϵ is the loaded zone parameter.

If P_{r1} and P_{r2} are the equivalent radial loads for rings 1 and 2, then with radial displacement ($\epsilon = 0{\cdot}5$) of the rings

$$Q_{c1,2} = P_{r1,2} \mathcal{J}_1(0{\cdot}5) / [Z \cos \alpha \mathcal{J}_r(0{\cdot}5)] \quad .. \quad (91)$$

and from eqs. (88), (89) and (91)

$$P_{r1,2}/F_r = \mathcal{J}_r(0{\cdot}5)\, \mathcal{J}_{1,2} / [\mathcal{J}_{1,2}(0{\cdot}5)\, \mathcal{J}_r]\,;$$

$$P_{r1,2}/F_a = \mathcal{J}_r(0{\cdot}5)\, \mathcal{J}_{1,2} \tan \alpha / [\mathcal{J}_{1,2}(0{\cdot}5)\, \mathcal{J}_a] \quad .. \quad (92)$$

If P_r is the equivalent radial load of the bearing, then

$$1/L = (P_r/C)^w = (P_{r1}/C_1)^w + (P_{r2}/C_2)^w \quad .. \quad (93)$$

and from eqs. (92) and (93):

$$\frac{P_r}{F_r} = \left[\left(\frac{C}{C_1} \frac{\mathcal{J}_r(0{\cdot}5)}{\mathcal{J}_1(0{\cdot}5)} \frac{\mathcal{J}_1}{\mathcal{J}_r} \right)^w + \left(\frac{C}{C_2} \frac{\mathcal{J}_r(0{\cdot}5)}{\mathcal{J}_2(0{\cdot}5)} \frac{\mathcal{J}_2}{\mathcal{J}_r} \right)^w \right]^{1/w}$$

$$\frac{P_r}{F_a} = \left[\left(\frac{C}{C_1} \frac{\mathcal{J}_1}{\mathcal{J}_1(0{\cdot}5)} \right)^w + \left(\frac{C}{C_2} \frac{\mathcal{J}_2}{\mathcal{J}_2(0{\cdot}5)} \right)^w \right]^{1/w} \frac{\mathcal{J}_r(0{\cdot}5)}{\mathcal{J}_a \tan \alpha} \quad (93*)$$

Furthermore, from eqs. (56) and (64)

$$F_r \tan \alpha / F_a = \mathcal{J}_r / \mathcal{J}_a$$

and $$(C/C_i)^w + (C/C_e)^w = 1 \quad .. \quad .. \quad (94)$$

With $v = \mathcal{J}_a\,(0{\cdot}5)/\mathcal{J}_1\,(0{\cdot}5)$, the values of v for $p = 3$ and different values of the exponent e are given in Table VI.

TABLE VI.

e	= 1	10/9	1·5	2	$3^1/_3$	∞
v (point contact)	1	1·04	1·17	1·26	1·41	1·78
v (line contact)	1	—	1·14	1·23	1·36	1·68

Then introducing the factor

$$V = \left[\left(\frac{C}{v\,C_e} \right)^w + \left(\frac{vC}{C_i} \right)^w \right]^{1/w} \quad .. \quad (95)$$

we have, for *radial* displacement ($\epsilon = 0{\cdot}5$) of the bearing rings, from eqs. (92) and (96)

$$P_r = V\,F_r\,;\quad V = v f_2 \left(\frac{C_i}{C_e} \right)$$

$$f_2\,(C_i/C_e) = \left\{ \left[1 + \left(\frac{C_1}{v^2 C_e} \right)^w \right] \Big/ \left[1 + (C_i/C_e)^w \right] \right\}^{1/w} \quad (96)$$

For fixed outer load, $C_1 = C_i$, and $C_2 = C_e$; for fixed inner load, $C_1 = vC_e$, and $C_2 = C_i/v$; P_r/F_r being obtained from eq. (93*).

If the inner ring is considerably weaker than the outer ring, that is, if $C_i/C_e \to 0$, then $V = v$. If, however, $C_e/C_i \to 0$, $V = 1/v$.

With *axial* displacement ($\delta_r = 0$) of the bearing rings

$$P_r = YF_a$$

$$Y = f_1\,(C_i/C_e)\,\mathcal{J}_r\,(0{\cdot}5)\,\text{cotan}\,\alpha/\mathcal{J}_1\,(0{\cdot}5) \quad .. \quad (97)$$

$$f_1 \left(\frac{C_1}{C_e} \right) = \left[\frac{1 + (C_i/vC_e)^w}{1 + (C_i/C_e)^w} \right]^{1/w}$$

With a fixed outer ring load, $C_1 = C_i$, and $C_2 = C_e$; with fixed inner ring load, $C_1 = vC_e$, $C_2 = C_i/v$; P_r/F_a is obtained from eq. (93*).

For non-self-aligning bearings consideration must be given to the effect of the manufacturing precision on the factor Y.

The *thrust factor* Y should be corrected for lack of parallelism between the rotating race and the stationary race, as this results in a decreased capacity for non-self-aligning bearings.

Experience and preliminary tests with *thrust ball bearings* show that manufacturing and other factors reduce the capacity to 60 per cent of the theoretical value. For angular contact ball bearings and tapered roller bearings,

$$Y_1 = f_1 \left(\frac{C_i}{C_e} \right) \frac{\mathcal{J}_r\,(0{\cdot}5)\,\text{cotan}\,\alpha}{\mathcal{J}_1\,(0{\cdot}5)\,(1 - 0{\cdot}4\,\sin\,\alpha_0)}$$

$$= \frac{Y}{1 - 0{\cdot}4\,\sin\,\alpha_0} \quad .. \quad .. \quad .. \quad (98)$$

where Y_1 = the corrected value.

For combined loads, eq. (93*) gives related values of F_r/P_r and $F_a\,\text{cotan}\,\alpha/P_r$. For practical calculations of single-row bearings we then have

for $F_a \leq \xi\,V\,F_r \tan \alpha$: $P_r = VF_r$

for $F_a \geq \xi\,V\,F_r \tan \alpha$: $P_r = X_1 VF_r + Y_1 F_a$ .. (99)

where $\xi = 1{\cdot}2/f_1\,(C_i/C_e)$ for deep-groove ball bearings and $\xi = 1{\cdot}5/f_1\,(C_i/C_e)$ for all other bearings. The radial factor X_1 can be found from

$$X_1 = 1 - \eta \frac{\mathcal{J}_r\,(0{\cdot}5)}{\mathcal{J}_1\,(0{\cdot}5)} \frac{1}{1 - 0{\cdot}4\,\sin\,\alpha_0} \quad .. \quad (100)$$

where $\eta = 1{\cdot}2$ for deep-grove ball bearings, and $\eta = 1{\cdot}5$ for all other bearings. The calculated values of Y are only applicable to deep-groove bearings if the groove depths are sufficiently great to support the contact angle induced by the load.

(2) *Double-Row Bearings*

The indices 1 and 2 are assigned to the ring rotating relatively to the direction of load, and the stationary ring, respectively, and the indices I and II refer to the corresponding rows. For a bearing without internal looseness $\epsilon_{\text{I}} + \epsilon_{\text{II}} = 1$ for $\epsilon_{\text{I}} \leq 1$, and $\epsilon_{\text{II}} = 0$ for $\epsilon_{\text{I}} \geq 1$. Both rows are loaded if $\epsilon_{\text{I}} < 1$, that is, if

$$F_a < \eta\,F_r \tan \alpha \quad .. \quad .. \quad .. \quad (101)$$

where $\eta = 1{\cdot}67$ and $\eta = 2$ for point and line contact respectively. Only one row is loaded if F_a is greater than $F_r \tan \alpha$. In this case the life of double-row bearings can be calculated either from the theory of single-row bearings or from that of double-row bearings.

If P_{r1} = equivalent radial load for the loaded row regarded as a single-row bearing, and P_r = equivalent load for the double-row bearing, then the bearing life can be obtained from either of the formulae

$$L = (C_{\text{I}}/P_{r1})^3 = (C/P_r)^3 \quad .. \quad .. \quad (102)$$

where $$P_r/P_{r1} = C/C_{\text{I}} = 2^{(w-1)/w} \quad .. \quad .. \quad (103)$$

For practical calculations, the formulae to be applied are:—

When $P_r \leq 2V\,F_r$

$$P_r = VF_r + Y_3 F_a \quad .. \quad .. \quad .. \quad (104)$$

and when $P_r \geq 2VF_r$:

$$P_r = X_2 VF_r + Y_2 F_a$$

$$P_{r1} = X_1 VF_r + Y_1 F_a \quad .. \quad .. \quad (105)$$

where V, X_1, and Y_1, have the same values as for single-row bearings, and

$$X_2 = 2^{(w-1)/w} X_1, Y_2 = 2^{(w-1)/w} Y_1 \quad .. \quad (106)$$

and $$Y_3 = Y_2/(2 - X_2)$$

(3) *Equivalent Thrust Load for Bearings*

The basic dynamic capacity C for thrust bearings is the constant thrust load which 90 per cent of the bearings will endure for 1 million revolutions. The same life formula can be used as above for various rotation and load conditions if, in place of the actual bearing load, an equivalent load thrust P_a is introduced. The life is then

$$L = (C/P_a)^3 \quad .. \quad .. \quad .. \quad (107)$$

the equivalent thrust load P_a being found from the equation

$$Y_a P_a = P_r \quad .. \quad .. \quad .. \quad (108)$$

Y_a is the bearing's thrust factor (Y_1 or Y_2) for pure thrust load*.

If the load of the bearing varies as a function of the angle of rotation of the shaft, the cubic mean value of the bearing load can be introduced as the equivalent bearing load. Another method of determining the equivalent bearing load, for a load which varies periodically with the rotation of the shaft, is given in the last reference of the Bibliography.

8. THE LIVES OF COMPLETE BEARING APPLICATIONS

Generally, several individual bearings are mounted in one support. If the applied bearing loads are known, the equivalent load of each bearing can be calculated

*P_r and Y_a can be found from a table given in the original article.

(with the aid of a table given in the original article), and the life of each of these bearings is then obtained by means of eq. (87). The life, which 90 per cent of a group of similar applications have, is determined by

$$\frac{1}{L} = \left[\left(\frac{1}{L_1}\right)^e + \left(\frac{1}{L}\right)^e + \ldots\right]^{1/e} \quad (109)$$

where $e = 10/9$ for ball bearings with point contact, and $e = 3/2$ for roller bearings with line contact. For applications with ball as well as roller bearings, a mean value of e can be introduced.

Example of Calculation.

An application consists of a cylindrical roller bearing with $C = 6{,}000$ kg, and a spherical roller bearing with $C = 22{,}000$ kg and a contact angle $\alpha = 14°$. The cylindrical roller bearing supports a radial load of 600 kg, and the spherical roller bearing a radial load of 2,000 kg and a thrust load of 300 kg. The shaft is stationary relatively to the load.

The equivalent load of the bearing is found from $P_r = VXF_r + YF_a$ and we find (from a table given in the original article) that for the *cylindrical* roller bearing $V = 1{\cdot}3$, $X = 1$, and for the *spherical* roller $V = 1{\cdot}3$ and

if $P_r \geq 2{\cdot}6\,F_r$: $X = 0{\cdot}6$, $Y = 0{\cdot}7 \cot 14° = 2{\cdot}8$,
if $P_r \leq 2{\cdot}6\,F_r$: $X = 1$, $Y = 0{\cdot}5 \cot 14° = 2{\cdot}0$.

For the *cylindrical* bearing: $P_r = 1{\cdot}3 \times 600 = 780$ kg, and $L_1 = (6000/780)^3 = 45$ million revolutions; and for the *spherical* roller bearing:

$P_r = 1{\cdot}3 \times 0{\cdot}6 \times 2000 + 2{\cdot}8 \times 300 = 2400$ if $P_r = 2{\cdot}6 \times 2000 = 5200$,

$P_r = 1{\cdot}3 \times 1 \times 2000 + 2 \times 300 = 3200$ if $P_r = 5200$, hence $L_2 = (22000/3200)^3 = 32$ million revolutions.

92 per cent of the cylindrical roller bearings used on this application thus ought to endure 45 million revolutions or more, and 90 per cent of the spherical roller bearings 32 million revolutions.

The life of this bearing application, i.e., the number of revolutions which it has a 90 per cent probability of carrying without requiring dismantling and replacement of parts, is then obtained from eq. (109):

$$1/L = [(1/45)^{3/2} + (1/32)^{3/2}]^{2/3} = 0{\cdot}0427,$$

so that $L = 23$ million revolutions.

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RUSSIA

Flow Conditions and Heat Transfer in Tubular Air Preheaters

By S. I. KOSTERIN and B. K. KOZLOV. (From *Izvestia Akademii Nauk*, No. 9, 1948, pp. 1445-1455, 11 illustrations.)

IN this paper the author gives an account of the flow conditions and heat transfer characteristics of a tubular air preheater designed to operate in conjunction with a boiler of 90-110 tons of steam per hour rated capacity. The principal dimensions of the air preheater are the following:

Heating surface	2100 m²
External tube diameter	70 mm
Internal tube diameter	65 mm
Number of tubes	2420
Tube length	4·0 m
Transverse pitch of tubing	108 mm
Longitudinal pitch of tubing	140 mm
Number of tubes per row	38
Number of tube rows	33
Effective gas flow area	8·03 m²
Effective air flow area	6·79 m²

As shown in Fig. 1, the air preheater is composed of two parts each of which is equipped with an independent induced draught fan and forced draught fan so that either half can be operated separately. The flue gases are made to pass through the tubes, while the air is made to sweep over the outer tube surfaces, the tubes being arranged in staggered formation. The investigations of the flow-dynamic and heat transfer characteristics on the air side and the flow-dynamic characteristics on the gas side were carried out on two models. The heat transmission was determined by the thermo-calorimetric method, nine thermocouples being installed in the tube walls for this purpose, while the flow conditions were studied with the employment of Prandtl tubes and silk threads.

In order to obtain the total flow resistance, the static pressure was measured at four points, namely (1) at the inlet of the admission box ; (2) at the end of the outlet box; (3) before the tube bundle and (4) after the tube bundle. As will be noted from Fig. 2, the respective $Eu = f(Re)$ functions of the assembled model and the tube bundle differ considerably, the assembled model of the air preheater having an Euler number of 18·0 for a Reynolds number of 3,000, while the Euler number of the tube bundle was 11·3 for the same Reynolds number. The graph shows that, in spite of the low Reynolds numbers prevailing, the Euler number proved to be constant and independent of the Reynolds number. The high flow resistance as indicated by the Euler number for the assembled apparatus can be explained by the unsuitable configuration of the air inlet box.

Referring to Fig. 3, it will be seen that the air stream

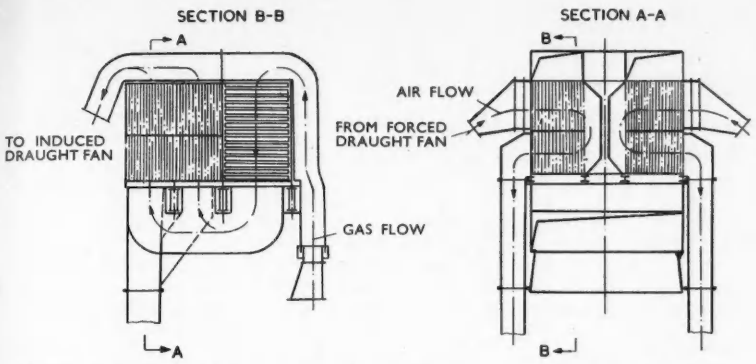

Fig. 1. **General outline of air preheater.**

in the air outlet box exhibits unequal velocity distribution, the inequality being greater in the horizontal outlet passage than in the vertical part connecting with the ascending duct. It will be noted in Fig. 4 that unequal flow distribution also exists in the air inlet box. The heat transfer coefficient was determined for each tube row separately, and for both the left-hand and the right-hand sides of the apparatus. The variation of the coefficient of heat transfer over the tube length was also ascertained. The original article gives the Nusselt number *versus* Reynolds number functionality as found for the various tube rows. Considering the air preheater as a whole, this functionality is expressed by the relationship $Nu = 0{\cdot}215\ Re^{0{\cdot}63}$. In Fig. 5 are shown characteristic curves indicating the variations in the heat transfer coefficient over the tube length, as found for four different rows of the tube bundle.

The influence of the configuration of the inlet and outlet boxes upon the flow distribution in the air heater surface is also evidenced by the flow characteristics prevailing on the gas side of the apparatus. This is illustrated by Fig. 6 which shows the presence of stagnant zones characterized by the vortex movement of the gases. As a consequence, the gas flow through the individual tubes lacks uniformity and the heat absorption is adversely affected, as is also the flow resistance.

In Fig. 7 is shown the gas velocity distribution as observed in the model of a combined economizer and air preheater installation. The gas flow distribution over the air preheater surface is seen to be unsatisfactory. In order to improve flow conditions, guide vanes were placed in the gas inlet box of the air preheater, but no

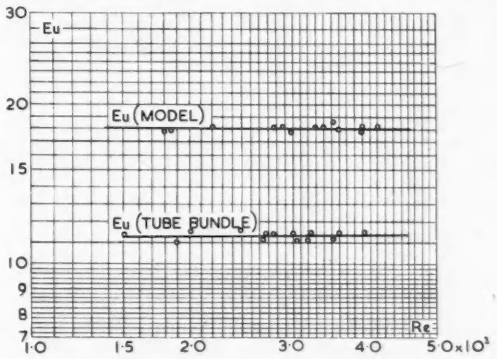

Fig. 2. **Flow resistance characteristics of air preheater model and air preheater tube bundle.**

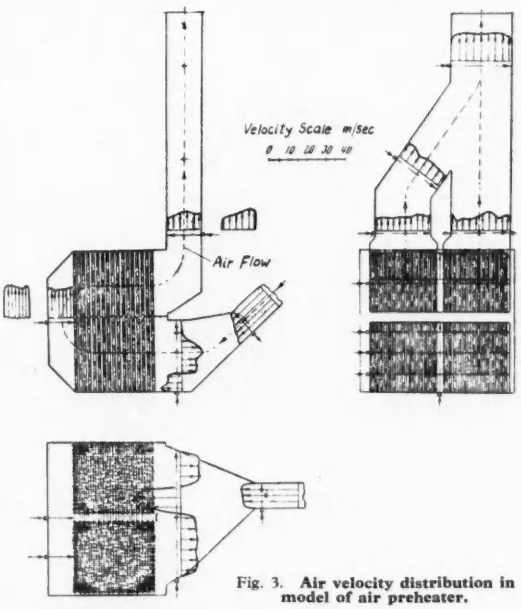

Fig. 3. **Air velocity distribution in model of air preheater.**

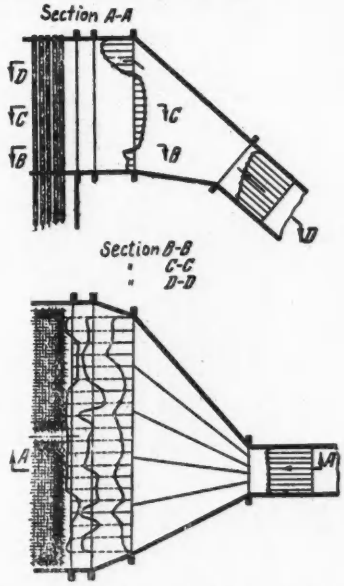

Fig. 4. **Air velocity distribution in inlet box.**

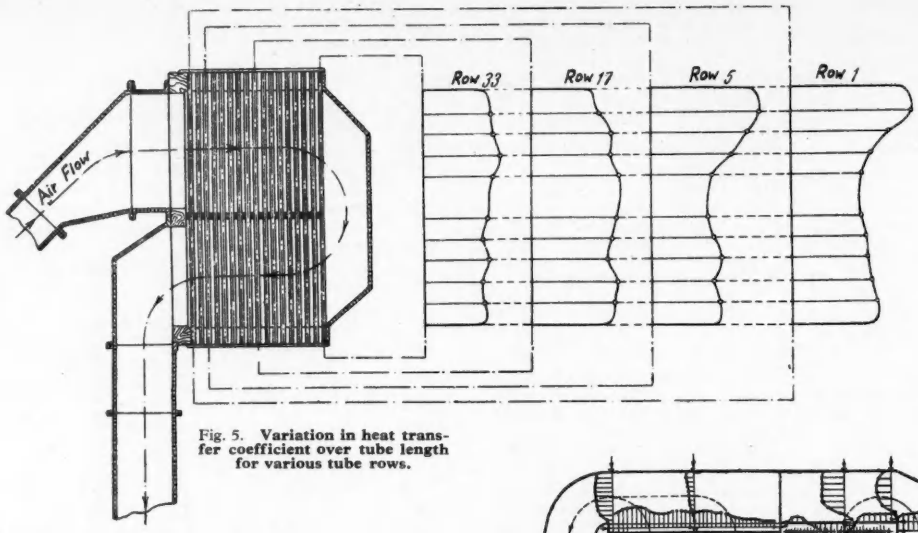

Fig. 5. **Variation in heat transfer coefficient over tube length for various tube rows.**

improvement was obtained. It was, therefore, decided to study the flow distribution in the economizer so as to explore the possibility of improving the flow conditions in the gas inlet box of the air preheater. This investigation revealed a highly unsatisfactory flow distribution of the gases in the economiser. The necessary steps were taken to enforce more uniform gas flow through the economizer, which resulted in a certain improvement in the flow conditions in the air preheater. Final success was obtained by installing the type of guide vane in the inlet box shown in Fig. 8. This led to the elimination of stagnant gas pockets and considerably improved heat transfer conditions in the air preheater surface.

Fig. 6. **Flow distribution on gas side of air preheater.**

Fig. 7. **Gas flow distribution in combined economizer and air preheater installation.**

Fig. 8. **Gas flow distribution in air preheater part of combined economizer and air preheater** (Fig. 7) **after installation of guide vanes and special baffles.**

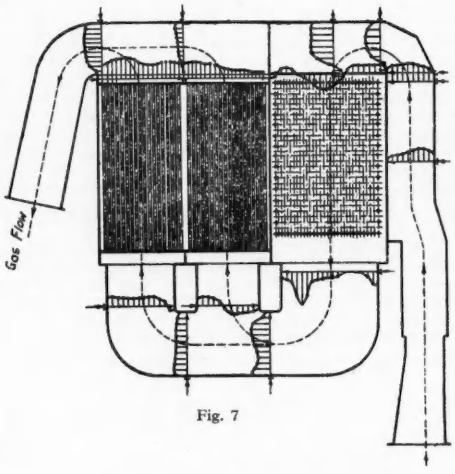

Fig. 7

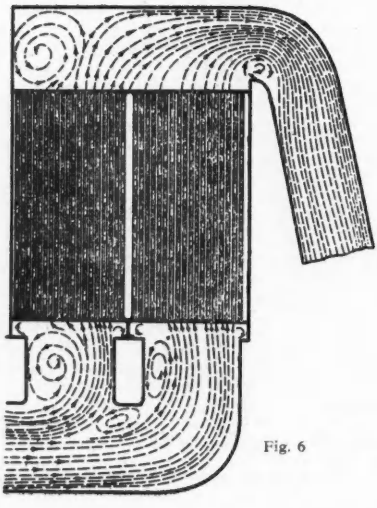

Fig. 6

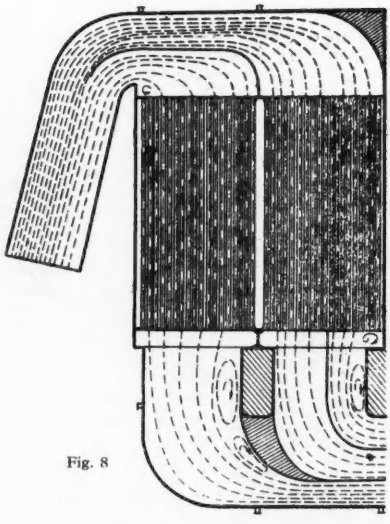

Fig. 8

DESIGN AND WORKSHOP

A Digest of articles of interest to Works Managers, Planning and Production Engineers, Superintendents, Jig and Tool Designers, Inspectors, Time Study Engineers, and all those concerned with the practical aspects of Engineering.

Multiple Spindle Drill Heads

By H. E. SCHEIBE. (From *Werkstatt und Betrieb, Germany*, Vol. 81, No. 11, November, 1948, pp. 309-315, 17 illustrations.)

IN view of the large amount of drilling and similar work done in workshops, a number of well-tried designs of special-purpose fittings, which convert bench and pillar drills, lathes, etc., into multiple-spindle special-purpose machines, are collated and illustrated in this article.

Special attention has naturally to be given to suitable design of each individual spindle. It should be as short as possible, and unless very close spacing requires location of the driving pinions in different planes, one main bearing will often suffice (Fig. 2). At high speeds, the use of ball bearings will suggest itself. Where they are required, one type should be used throughout. As shown in Fig. 1, for instance, deep-groove ball bearings will not only effect radial location but also take the thrust. Axial location may be effected by external and internal circlips. Working tolerances in their mutual spacing are taken up by shims.

Where spindles are closely spaced, and where speeds are low, *bedded* journal bearings may be used in conjunction with a thrust bearing (Fig. 2), provided that care is taken to give adequate lubrication, preferably from a central reservoir (Figs. 4, 5).

End play must be avoided, as it may cause excessive breakage to smaller drills, or chatter. Means for adjustment are, therefore, of importance, and attention is directed to the slotted locknut (see detail *n*, Fig. 4) which may provide a simple but sound solution to many of these problems.

Nearly all the devices shown are intended to be clamped to the spindle-bearing cover of normal pillar or heavy bench drilling machines. It is, therefore, necessary to guard against excessive weight. Light

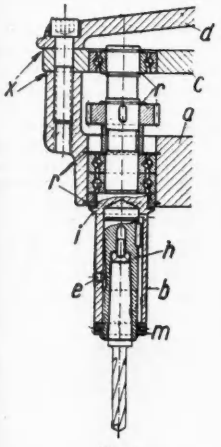

Fig. 1

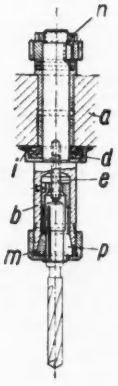

Fig. 2

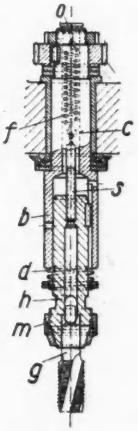

Fig. 3

Fig. 1. **High Speed Drill Spindle.**

a base casting of housing; *b* spindle shaft; *c* bearing plate; *d* cover of housing; *e* grub screw; *h* taper sleeve; *m* nut for adjustment.

Fig. 2. **Simple spindle with collet chucks.**

a base of housing; *b* spindle shaft; *d* thrust bearing; *e* adjusting screw; *i* cover ring; *m* nut for tightening collet *p*.

Fig. 3. **Tapping spindle.**

b spindle shaft; *c* bore for spring *f*; *d* compression spring; *g* tap; *h* holder sleeve; *m* nut for tightening; *o* eye for location of spring *f*; *s* adjusting screw.

Fig. 4. **14-Spindle drill head.**

a housing cover; *b* spindle shaft; *c* bearing plate; *d* stub shaft for main gear *z*; *g* base casting; *h* holder sleeve; *k* morse taper adaptor; *m* adjusting nut; *n* lock nuts, *r* pinions; *s* locking screw for chuck.

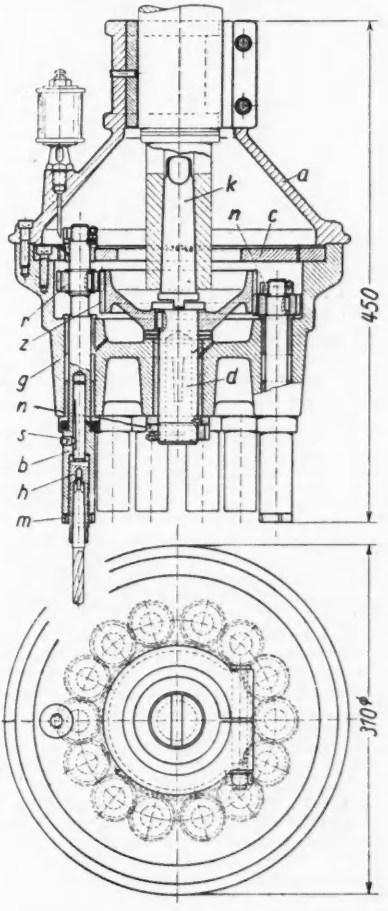

Fig. 4

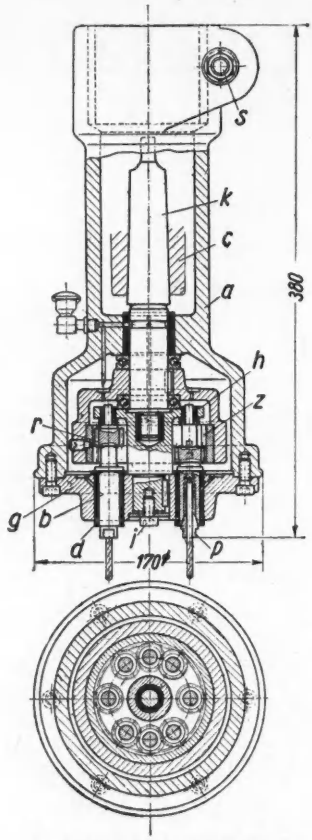

Fig. 5 (left). **8-Spindle drillhead.**
a housing ; *b* spindle shaft ; *c* main spindle of machine ; *d* bushings (press-fit on *b*) ; *g* base casting ; *h* bearing holder ; *i* screw ; *k* morse taper shaft ; *p* collet, *r* pinions ; *z* internal gearwheel.

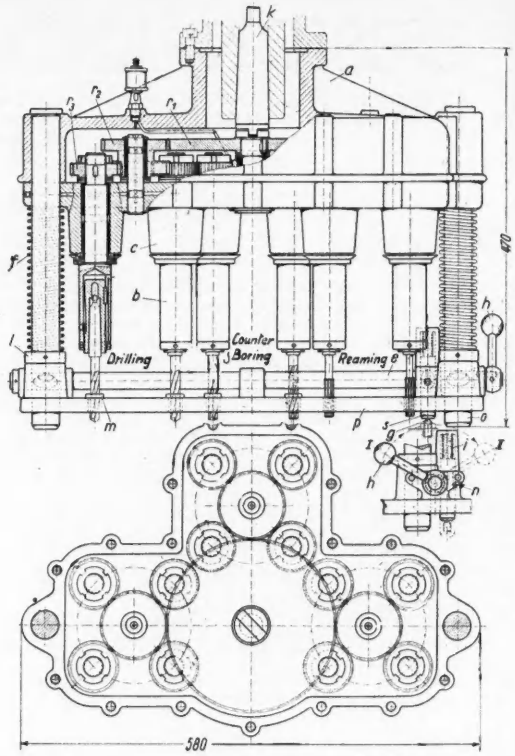

Fig. 6 (right). **12-Spindle drill head for simultaneous drilling, counterboring and reaming.**
a main casting ; *b* spindle shafts ; *e* shaft for locating plate *p* *f* compression springs ; *i* compression spring which secures *e* unless plunger *s* is in contact with set-screw *g* ; *k* adaptor ; *l* set collars ; *m* drill bushes ; *n* limiting set screw ; *o* guide columns ; r_1, r_2, r_3 spur gear drive.

alloy castings may be adopted with advantage in many cases, and in others, counterweights may be considered for avoiding interference with the feed arrangements.

A number of designs will now be described by way of example.

Fig. 1 shows a high-speed spindle provided with deep-groove ball bearings. It is seen that both base and bearing plate have location holes for bearings of the same diameter, which can thus be jig-bored in one setting, assuring both economy and good alignment. One important feature of the drill chuck assembly is the provision for axial adjustment of sleeve *h* relative to sleeve *b* by means of nut *m* and grub screw *e*, by which the depth of the individual holes may be varied. Torque is transmitted by a feather key between *h* and *b*. The collar *i* on the spindle is intended to protect the bearing against cutting lubricant and swarf.

Fig. 2 shows a much less ambitious and more economical spindle. Location of the bearings in and against the baseplate has only the obvious advantage of simplicity. End play is taken up by nut *n* against the plain thrust bearing *d*. Set-screw *e* provides adjustment for variations in drill length. A spring collet holds the plain shanked drill, being clamped by nut *m*, which at the same time guards against expansion of the sleeve *b*.

The tapping spindle shown in Fig. 3 may be of special interest. The bearing design is identical with that of Fig. 2, but a sleeve *h*, similar to its counterpart in Fig. 1, floats freely in spindle *b*. Initial feed pressure is given by the compression spring *d*, whereas during the remainder of the cutting time the tap pulls itself into the bore. Tension spring *f* facilitates return at the end of the operation, and prevents accidental disengagement of *b* and *h*. Feed is preferably by hand. If automatic, the entry must be slower than the pitch of the thread, and the return somewhat faster. Location of the tap is done by the threaded sleeve *m*, which compresses the end of *h* as an inverted collet.

Fig. 4 shows a straightforward 14-spindle attachment, arranged to be clamped to the bearing housing of a pillar drill. The morse taper *k* drives spur gear *z* via the spindle *d*. The pinions on the spindle are staggered in height to save space. The bearings are plain bushings throughout, and the drills are held as described in Fig. 1. Axial play is taken up by the nuts *n*, which press against thrust rings running on the shouldered bushes pressed into bearing plate *c*. The careful provision of lubrication from one drip oiler should be noted. Light alloys may well be used for the castings of this head.

Fig. 5 shows a much smaller 8-spindle head. Again, the whole fitting is to be clamped to an ordinary drill, and a taper adaptor *k* is used. A wheel with internal gear *z* is attached to this adaptor by a feather key. Economy of space is achieved by the central mounting of the bearing plate *h*. The drills are located by collets *p*, which are screwed into spindles *b*. To avoid ex-

pansion of the latter as the collets are tightened, the bushes *d* have been pressed onto spindles *b* rather than into base *g*. Here, again, much thought has been given to lubrication.

Many variations are possible with basically similar components. One of the more interesting is seen in Fig. 6, where an automatic sequence of drilling, counterboring and reaming of 4 holes is achieved with obvious economy on one machine. The work-piece is located on a four-position jig (swivelling concentrically with the main spindle) in the empty position, and fed successively to the drilling, counter-boring and reaming position and unloaded as it completes its round. Accuracy is maintained by the drill bushes in plate *p*, which is located by guide rods *o* passing through the main casting of the drill head, and pressed down on the work by springs *f*. To facilitate changes of the plate (when starting on a batch of different diameters), it is fixed to the guide rods *o* by shaft *e*. This is partly milled away to clear the rods, but, if turned by handle *h*, engages milled recesses in them. Set collars *l*, which are pinned to the rods, give final location and transmit the thrust of springs *f*.

Fig. 7 depicts the assembly of an adjustable drill head, which is shown with 6 spindles in place. Each spindle is a self-contained unit, adjustably fixed to the concentrically slotted base of casting *c* by bolts passing through the slotted holder *h*. The drive is taken from the main spindle through the taper shanked spur gear *k*, through pinions *r*, to the spindles, by two universal joints connected by a telescope shaft *v*. Clearly, any number of units may be detached if only a few are required, and the flexibility of this piece of equipment makes it useful where relatively small series are produced. While this assembly has been designed for clamping to a drilling machine, attachments may be designed for the conversion of lathes into horizontal boring machines, etc. (cf. ref. 1).

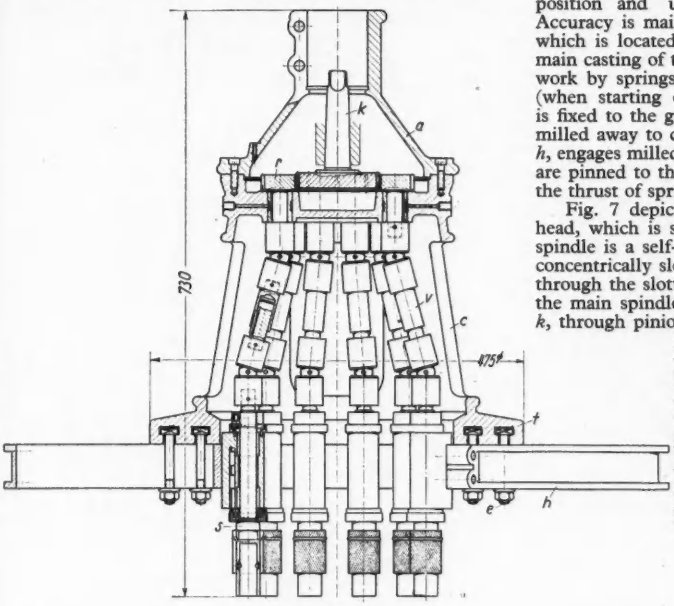

Fig. 7. Adjustable head.

a top-housing ; *c* support base ; *e* square-headed bolts ; *h* spindle holder ; *k* morse taper adaptor ; *r* spur gears and stub shafts ; *s* spindles ; *t* slots for *e* ; *v* telescope shafts.

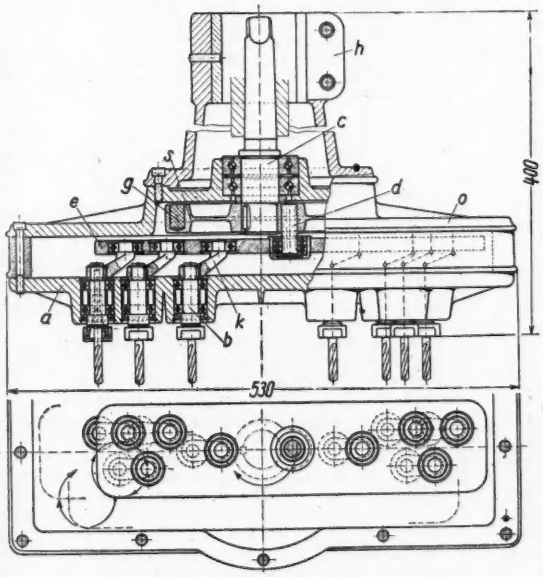

Fig. 8. Crank driven drill head.

a base plate casting ; *b* spindle shafts ; *c* main drive spindle ; *d* main crank pin ; *e* driving plate ; *g* lead slugs ; *h* casing for clamp fixing ; *k* driving cranks ; *o* cover plate ; *s* fly wheel.

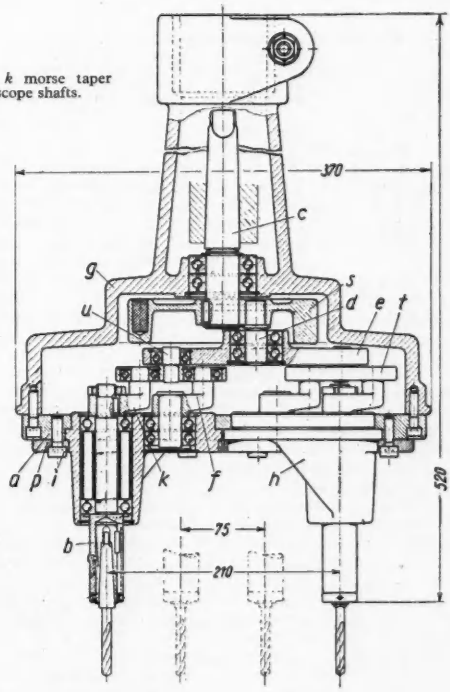

Fig. 9. Crank driven adjustable heads.

a baseplate ; *b* spindle shaft ; *d* crankpin ; *e* driving plate ; *f* guide cranks ; *g* housing ; *h* rotatable holder casting ; *i* clamping screws ; *k* spindle cranks ; *p* clamping plate ; *s* flywheel ; *t* intermediate driving plates ; *u* connecting pins.

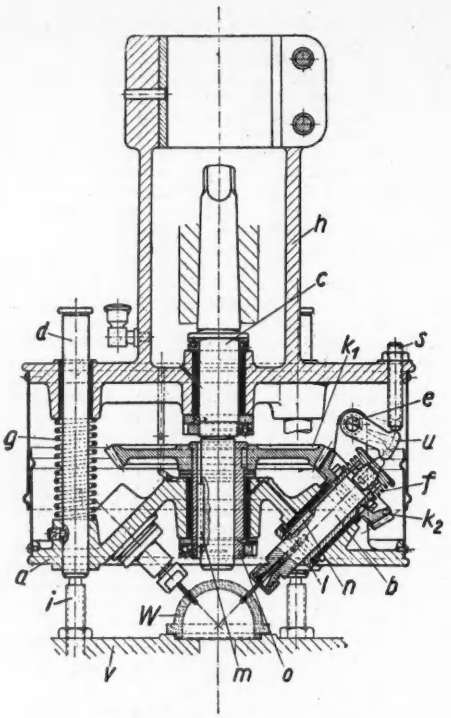

Fig. 10. **3-Spindle head for inclined holes.**
a base casting ; *b* spindle shafts ; *c* main spindle ; *d* guide columns; *e* bolts ; f_1 *g* compression springs ; *h* main casting ; *i* set screw ; k_1, k_2 bevel gear drive ; *l* bearing bushes for spindles ; *m*, *n* feather keys ; *o* sleeve, *s* adjusting screw ; *u* cam lever ; *v* jig for work-piece *W*.

Fig. 8 shows a modification to the drive of an otherwise normal head. Where the spacing of the spindles is quite irregular and gearing would be difficult and expensive to arrange, a crankdrive is a handy solution. The main crank-pin *d* is pressed into the flywheel *s*, which is balanced by lead slugs *g*, and driven by *c*. The transmission is completed by driving plate *e*, into which are pressed the bearings for the main crank pin *d* and the final cranks *k*. It will be appreciated that plate *e* and base *a* should be jig-bored in the same setting, with resulting economy. This transmission runs remarkably quiet. As a further elaboration (Fig. 9) an adjustable head may be built. Intermediate plates *t* and guide cranks *f* are provided, and each assembly of spindle and guide crank may be rotated about the centre of casting *h*, which is secured to the base *a* by clamping plate *p*. It is, of course, important that the centre distances of the pins *u* and castings *h* should be equal.

An interesting special fixture is sketched in Fig. 10. This will drill three holes inclined to each other, so that the downward feed of the main spindle has to be converted into an inclined motion of each working spindle. The drive is transmitted to sleeves *l* by bevel gears k_1, k_2, and from there to spindle shaft *b* by feather key *n*, which permits wide axial float. Compression spring *f* presses the shaft away from the work against cam lever *u*, which rests against screw *s*. The whole base assembly (casting *a*, guide rods *d*, and drive up to bevel gear k_1) can now move relative to the main spindle nose and casting *h*, which, in turn, carries the screws *s*. Such motion is, however, prevented by springs *g* until downward feed of the main spindle brings guide rods *d* into contact with set screws *i* on the work table. From there on, only casting *h* will move further down, pressing the spindles *b* inwards by means of set-screws and cam levers *u*. As the main spindle is returned, the springs *f* and *g* will extract the drills from the work before permitting the base assembly to rise.

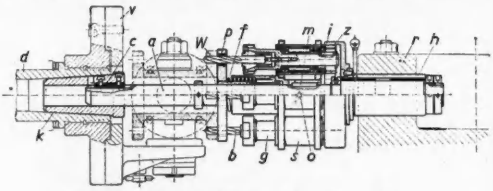

Fig. 11. **4-Spindle drill tool for turret lathe.**
a drive shaft ; *b* spiral drills ; *c* key between adaptor *k* and shaft *a* ; *f* compression spring ; *g* spindle shafts ; *s* spindle housing ; *p* plate for drill bushes ; *i* internal spur gear ; *z* pinions, *m* feather key ; *o* locking screw ; *v* jig, *W* work-piece.

Needless to say, many more special arrangements have been devised. Reference to some is made in ref. (2), and especially the construction of a multiple drilling attachment to a standard turret lathe is described in detail. Briefly, a light head is mounted in the turret, so that it is free to rotate. The head is then caused to revolve in step with the work by engagement with it, the drills being driven by pinions off the stationary internal gear (Fig. 11). Such a device not only saves working time, but also transfer and loading on to another machine.

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(1) WERKSTATT UND BETRIEB, Vol. 79, 1946, p. 168, fig. 3.
(2) H. E. SCHEIBE, VORRICHTUNGSBAU, WERKSTATTKNIFFE, Folge 17, 1948, p. 43.
CARL HAUSER VERLAG, Munich.

"Dry" Plating Process

(From *Electrical Engineering, U.S.A.*, November, 1948, p. 1103.)

A PROCESS of metal plating by means of a gaseous medium has been successfully developed by The Commonwealth Engineering Company of Dayton, Ohio. Heat is the sole means of deposition in the gas-plating process, which involves the thermal decomposition of metal carbonyls in an inert atmosphere of carbon dioxide.

Objects to be plated are radiant-heated in a plating chamber supplied by a metal carbonyl generator, in a closed system which re-circulates the plating gases for economy of operation. A integral metal coating is quickly obtained at temperatures of approximately 400° F, and the "dry" process is applicable to any material which will withstand this temperature range. Rate of uniform deposition is far higher than that of conventional electroplating, and irregular surfaces, complex shapes, and articles with internal areas are readily handled.

The process is ideally suited to the continuous plating of strip moving at fairly high speeds. In a laboratory test operation utilizing a small experimental unit, 13 pounds, 6 ounces of nickel was deposited in a 60-minute, single-pass plating cycle. In another operation on continuous strip an amount of metal which would have required 30 minutes to apply by conventional plating methods was deposited in four seconds.

Carbonyls of a number of metals, including nickel, iron chromium, tungsten and molybdenum, may be used in the process. Surface preparation for gas plating is the same as for electrolytic plating. Control of the process is relatively simple, however, without the complicating factors of complex baths, delicate solution balances and intricate electrodes presently involved in wet plating.

Couplings for Built-up Crankshafts and their Behaviour under Load

By G. SIMONETTI*. (From *Tecnica Italiana, Italy*, Vol. 3, No. 5, September-October, 1948, pp. 261-265, 9 illustrations.)

IN large multi-cylinder engines it is not always possible or convenient to employ a solid crankshaft, so that a built-up crankshaft is frequently necessary.

The normal practice is to use a built-up crankshaft with a flanged coupling. The flanged sections then have to be supported on either side of the coupling, and this results in an increased weight of the entire engine. To avoid this extra weight, crankshafts have been developed which have a flanged section coupled directly to a crank-web. In most cases, the coupling requires a web of much greater thickness than the normal web, and consequently the cylinder spacing of the shaft section including the coupling is also greater. Although, with this arrangement, the shaft length and weight are not considerably increased, the various shaft sections have to be specially designed and are not interchangeable.

In order to eliminate this drawback, a special type of coupling has been developed in which the flanged section fits completely within a recess in the web of normal thickness. This arrangement can be applied to any crankshaft type, so that an engine can be equipped either with a built-up or a solid crankshaft.

It had originally been foreseen that the crankshaft with this recessed coupling would be subjected to practical tests and stressed up to acceptable limits not exceeding the stress amplitudes calculated for the normal types of couplings produced up to the present time. However, as the crankshaft has to sustain combined stresses which are not easily calculated, it was decided to carry out comparative tests on a standard crankshaft with a semi-recessed coupling, which was already available, and on a model crankshaft incorporating the new coupling, in order to determine the effective stresses occurring under actual working conditions.

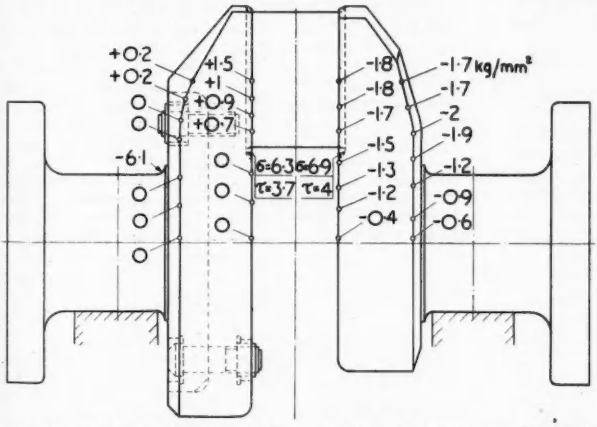


Fig. 1. **Stress distribution in model crankshaft with fully-recessed flanged coupling in web of normal thickness.**

Stress measurements were, therefore, carried out on a crankshaft for a 12,000 hp engine. This crankshaft with a semi-recessed coupling had a slightly increased cylinder spacing for the coupling section. The study of the proposed system, illustrated in Fig. 1, with equal spaces between cylinder centres and a fully-recessed coupling, was made by taking stress measurements on a smaller size model crankshaft.

*This article is based on data reproduced by courtesy of the Marine Engines Division of the FIAT Company.

Only bending tests were made on the full-size crankshaft, in view of the obvious difficulty of setting up equipment capable of applying to this crankshaft with a journal of 500 mm (19·688 inches) a sufficiently high torsional load to obtain appreciable shear stresses. Furthermore, calculations had shown that the bending stresses were predominant, and accordingly the investigation was limited in this case to the study of the bending stresses. The tests were carried out with various types of loading, as shown in Figs. 2a, b, and c.

In the first test, the crankshaft was supported at its extremities and relieved of its dead weight by a hydraulic jack applied at the middle of the crankshaft, and the shaft axis was thus absolutely horizontal. In this position, the strain gauges and measuring instruments were fixed at appropriate positions along the shaft, and the shaft was, thereafter, subjected to a bending load obtained by removing the hydraulic jack so that the shaft was deflected by its own weight. An additional load was applied by means of a second jack giving a load P acting vertically downwards.

In the second test the shaft was supported at one end and at the centre position, the load consisting of the dead weight of the partly overhung shaft and an additional load P obtained by means of an hydraulic jack. Here again, the shaft axis was first brought up to the unstressed horizontal position by means of jacks before fitting the strain gauges, and the jacks were then removed before each measurement. The third test was a repetition of the second with the crankshaft rotated through an angle of 180 degrees. Stresses were measured by means of a Huggenberger extensometer with a 10 mm gauge length.

The tests carried out under the various loading conditions described above gave substantially similar results. The following lines refer to the results obtained during the first series of tests with the shaft supported at both ends and loaded at the centre.

Under these conditions, a stress of 2·7 kg/mm² was measured in the crankpin adjacent to the coupling flange. The corresponding stress peak in the internal transition from the crankpin to the web was 13·0 kg/mm² for the solid web, and 10·8 kg/mm² for the web with the semi-recessed coupling. The stresses along the main web axis on the inner web surface decreased rapidly with increasing distance from the crankpin transition, and became practically equal to zero below the crankshaft axis (see Fig. 3). Owing to the particular load distribution obtained, the bending moment of the solid web was slightly lower than that of the built-up web, so that with similar bending moments on both webs the difference in the stresses at the transitions would have been even more pronounced.

Stresses of similar magnitudes were measured on the outsides of the crank throw. A stress of 10·8 kg/mm² was measured at the fillet of the journal on the coupling side, while a corresponding stress of 13·5 kg/mm² was recorded on the fillet of the solid web and journal. These results and the values of the stress-concentration coefficients at various positions on the web are shown in Fig. 3.

In the course of these series of tests, a number of check tests were also made to determine whether, as a result of the applied bending load, any elongation or

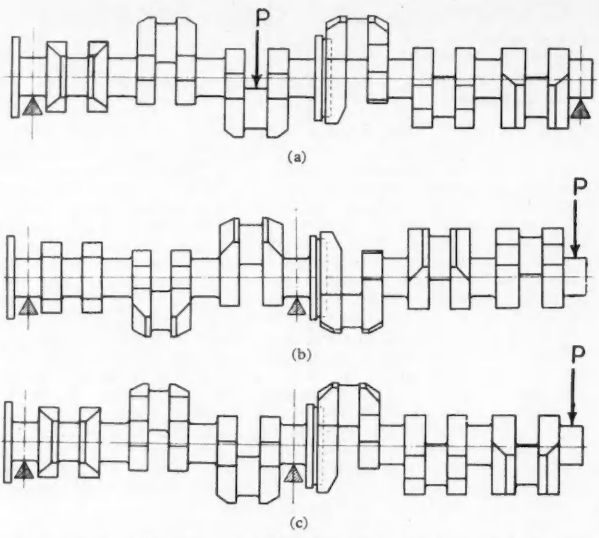


Fig. 2. **Full-size built-up crankshaft, with semi-recessed coupling, subjected to various types of loading.**
(a) Shaft loaded at centre and supported at the two ends.
(b) Shaft loaded at overhung end and supported at the other end and at the centre.
(c) Shaft as in b, but rotated through 180 degrees.

relative movement would occur in the coupling proper. For these checks, clock-gauge micrometers were mounted on the coupling bolts, and Huggenberger extensometers were also fitted so as to indicate any relative displacements of the coupling portions. No movement of any kind was observed during any of these tests, and it can, therefore, be stated that the built-up web behaves in the same way as the normal solid web.

The model crankshaft with the new fully-recessed coupling contained within a normal web section was a crankthrow, scaled down in the ratio 1/5 of a 4,500 hp engine with a journal diameter of 460 mm (18·134 inches), as shown in Fig. 1. The model was placed on two brackets supporting the journals, and in view of its smaller size, it was possible to test this crankshaft in torsion and bending at maximum permissible loads.

Bending stresses were generated by applying a load of 8,500 kg by means of an hydraulic jack, at a crankpin position corresponding to 15 degrees crank-angle after T.D.C., this load being equivalent to the load generated by a pressure of 60 kg/cm² in the combustion chamber of the actual engine.

For torsional tests, one of the end flanges was clamped, while the other was subjected to a torque of 300 kgm.

The measurements were made with Huggenberger 10 mm gauge-length extensometers, and Lehr 2-mm gauge-length photoelectric cell type strain gauges for not easily accessible parts.

A considerable number of measurements was taken along the crankpin periphery and on the inner sides of the two webs, the torque being applied first at one end of the shaft and then at the other.

Fig. 1 gives some of the most significant stress amplitudes obtained experimentally, and these show that the stresses of the crank-web on the coupling side are slightly lower than those for the solid web. The difference in the plus or minus signs depends on the direction of the stresses on the webs.

Owing to difficulties in installation, and in order to avoid taking measurements giving insufficiently reliable results at discontinuities, the Lehr strain gauge was only applied at certain positions on the curved transitions and fillets; consequently, the recorded values are not absolute maximum stress amplitudes. This also explains why the stress amplitudes for corresponding deflections at the transitions are somewhat lower on the small-size model than those determined on the full-size crankshaft.

CONCLUSIONS

The results of the static tests carried out indicate that the flanged couplings of the type considered are as strong as, or even superior to, the couplings commonly used in built-up crankshafts.

The tests confirmed, furthermore, the good results so far obtained in all cases where these new fully-recessed couplings were actually used in engines.

A remarkable fact, which cannot easily be explained by a first examination, is that the stresses in the coupling under consideration are lower than those encountered in a solid shaft. This result has been confirmed both on the model and on the full-size crankshaft.

Lastly, the tests have also confirmed that it is possible to design a crankshaft with a recessed coupling situated within a web of normal thickness, without it being necessary to increase the distance between the cylinder centres on either side of the flanged coupling.

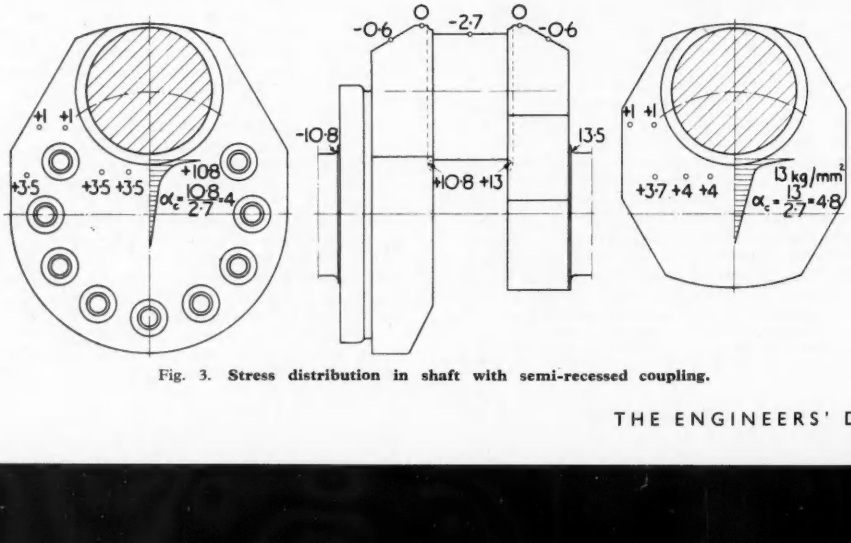


Fig. 3. **Stress distribution in shaft with semi-recessed coupling.**

BRITISH INDUSTRIES FAIR 1949

MAY 2-13

The greatest national trade fair in the world, the British Industries Fair, will be held in London and Birmingham from May 2nd-13th. As previously, the Engineering & Hardware section will be housed at Castle Bromwich, Birmingham, and other sections, covering chemicals, scientific instruments, optical and photographic goods, radio, office appliances, plastics, textiles and domestic appliances, will be seen at Olympia and Earls Court, London.

The British Industries Fair will demonstrate the ever increasing efforts of British manufacturers to improve the quality of their products, particularly in order to meet the requirements of overseas buyers, and will not fail to impress visitors with the high standards which are being maintained. New developments in raw materials and finished products will be on view, and will present visitors with an outstanding opportunity to become familiar with modern trends in manufacturing technique and equipment in Great Britain.

In the limited space at our disposal, we have been able to bring only a limited number of descriptions of outstanding products shown by some of the exhibiting firms, but it is hoped that this will be sufficient to indicate the diversity and attractiveness of the exhibits.

George Angus & Co., Ltd., Newcastle-upon-Tyne, will be exhibiting at Stand D.711, Birmingham, and as on previous occasions will be showing a complete range of Angus products including Transmission Belting, Oil Seals, Industrial Leather Products, Machine Cut Gearing, Fire Fighting Equipment, Industrial Protective Clothing, etc. Also included will be their new Gamax Epicyclic Geared Motor Unit. The Gamax unit is an epicyclic reduction gear mounted directly on to the end-shield of an electric motor forming a very compact straight line drive. There is only a very slight increase in the overall length of the motor, and the weight of the gear unit including adaptor is a mere 4½ lb. Units now in production have a fixed ratio of 4.5 to 1 and are designed primarily to suit " Brook " A.C. " CUB " fractional H.P. Motors which are supplied as standard unless otherwise specified, but the units can be readily adapted to many A.C. and D.C. fractional H.P. motors of other makes. Similar units having higher ratios will shortly be available. A range of three output speeds is made possible by the choice of motor speeds and the gear unit is capable of transmitting a maximum of 1 horsepower at a motor speed of 1500 r.p.m. and proportionately lower powers at reduced motor speeds. Both foot and flange mounting units are available and in either case five different types of output drive can be supplied. An integral flanged coupling makes the basis of a compact straight line drive, while the alternative forms of drive are crowned belt pulley, Vee-Pulley, Chain Sprockets, or 1⅛ in. diam. bareshaft extension on which users may mount a spur, helical or bevel pinion in order to obtain a further reduction in speed. The output member of the gear unit is supported on the motor shaft by Hoffmann ball and roller bearings of ample proportions.

The British Ermeto Corporation Ltd., Maidenhead, will be exhibiting at Stand D/723, at Birmingham, their range of Ermeto pipe couplings, patented throughout the world.

The joint of the Ermeto coupling consists of a body portion, a nut, and a sealing ring, and resembles an ordinary compression joint. Ermeto joints, however, are not compression joints. The ring is not compressed on to the surface of the pipe, as in ordinary joints. As the nut is progressively tightened, the sealing ring moves along the pipe and at the same time cuts into it. In this way the ring is made to throw up in front of it a ridge of displaced metal, and it is this metallic interlock which is the unique feature of the joint. It is the secret of the extraordinary pressure-holding qualities of Ermeto Couplings. Because of the cutting action of the sealing ring, an Ermeto joint is made on a surface of freshly cut metal. Any grooves or other inequalities in the surface of the pipe are cut through. The depth of cut is controlled and there is no fear of cutting so deeply that the pipe is weakened. During the making of the joint, the ring is altered in shape, and its leading edge becomes embedded in the pipe. When the joint is broken the ring remains permanently attached to the pipe-end. Because of this, Ermeto joints can be broken and remade almost indefinitely without affecting their efficiency. In addition to acting as the sealing member the ring also functions as a spring washer between the nut, the coupling body, and the surface of the pipe. For this reason, Ermeto couplings remain completely pressure tight even after prolonged periods of heavy vibration.

The **British Oxygen Co., Ltd.,** will be exhibiting two new models of B.O.C. hand cutters known as the Cutogen No. 1 and No. 2. The Cutogen No. 1 is designed to cut mild steel sections up to ¾ in. thick and also sheet metal using the specially stepped nozzle. The Cutogen No. 2, shown here in Fig. 1, is designed as a general purpose tool, covering the range of the No. 1 and also capable of cutting mild steel sections up to 12 in. thick. Each type incorporates many novel features. The metal parts of the cutters are finished in chromium plate, while the hand grip and valve control knobs are moulded from hard shockproof plastic material, the latter coloured black (oxygen) and red

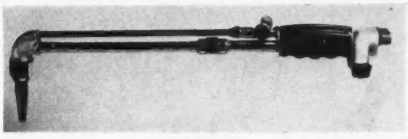
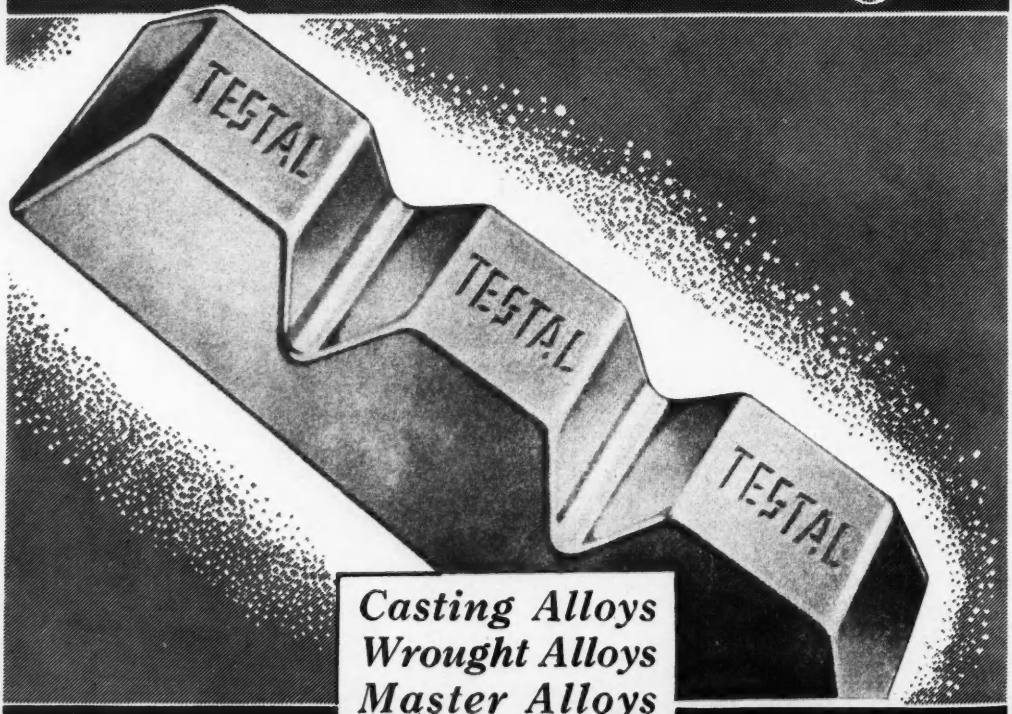


Fig. 1

(fuel gas) to facilitate identification. A new anti-backfire injector is a feature on both cutters, as also are the self-sealing valve glands for the heating oxygen and fuel gas " finger tip " controls. The cutting oxygen valve is thumb controlled and in the open position there is a straight-through passage for the oxygen cutting stream which flows in a streamline form right to the tip of the nozzle. The oxygen and fuel gas hose connections on both cutters are distinguished by coloured plastic rings and the connections conform to B.S.S. 1389/1947. Both these blowpipes are fitted with the new B.O.C. anti-flashback one-piece nozzles. One-piece nozzles are available for use with acetylene or alternative fuel gases.

TESTAL

Aluminium Alloys



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The latest developments in Argon Arc welding equipment, particularly for the welding of aluminium, aluminium alloys, stainless steel, Everdur, etc., are exemplified by the manual water cooled torch (Mk. III), shown here in Fig. 2, the machine water-cooled torch

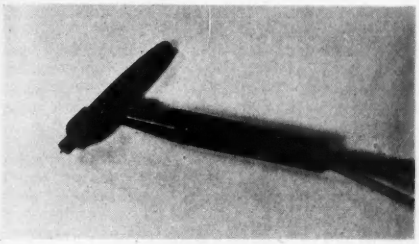

Fig. 2

(Mk. IV) and the 300 ampere composite set comprising the high frequency unit, the suppressor and the transformer. These torches allow for much heavier welding currents and, in consequence, thicker sections of material can be welded at increased speeds. Included in the Mk. III outfit is a new master valve which is incorporated in a rest for the torch, when not in use. This automatically cuts off the supply of Argon and also the High Frequency current, when accommodating the torch.

The British Thomson Houston Co., Ltd., will have at Stand C.511 and 410, Birmingham, a particularly spectacular exhibit, namely, a 275,000-volt oil break circuit-breaker unit designed for use in large outdoor switchgear installations. This circuit-breaker exceeds ten tons in weight, stands over 23 feet high from the ground to the tops of the insulators, and has an oil tank—shaped like a watch case—over ten feet in diameter and six feet in depth.

B.T.H. gas turbine work will be represented by a model of a 1,200 horsepower gas turbine-alternator for marine propulsion. The actual unit is now being built in the B.T.H. Rugby Works for the Anglo-Saxon Petroleum Co., Ltd., and will, in due course, be installed in the Tanker " Auris," in substitution of one of the present four diesel-electric units, so that exhaustive and comparative tests can be carried out under service conditions at sea.

Another marine exhibit will be the latest B.T.H. marine radar display unit, while models will show a typical marine radar layout on board ship.

A standard EMOTROL (electronic motor control) equipment will be demonstrated : it provides automatic speed variation to within plus or minus two per cent, over a wide speed-range, current limit control, acceleration at constant current and dynamic breaking.

The exhibits will also include fractional horse-power motors, geared-motor units of various sizes, half and quarter horse-power industrial " die-cast " motors, and several types of industrial control gear units ; a thrustor has been modified for exhibition purposes by replacing the standard oil tank by one made of " Perspex," enabling visitors to see the simple but effective operation of a B.T.H. thrustor under actual working conditions.

There will also be stator and rotor units for building into machine tools ; sud pumps ; FABROIL silent gears ; WINDONUTS for oil-level inspection and similar applications. Some large photographs will recall the important part being played by B.T.H. in the provision of heavy electrical plant and equipment for the generation of electric power and its application in Industry.

Products from various of the twenty-odd companies of the **Brockhouse Organization** will be shown at Stand Number D/405/304, Birmingham.

J. Brockhouse & Co., Ltd., West Bromwich, will be showing drop forgings, cold rolled sections, castings, and general accessories.

J. Brockhouse & Co., Ltd., Wolverhampton, are exhibiting the Brockhouse-Marchant Fuel Meter. This component, which replaces the carburettor on a petrol engine, is applicable to any type of internal combustion petrol engine. The same firm will also be showing the Brockhouse Paper Shredding and Crimping Machine, which converts waste paper or documents into valuable packing material.

Brockhouse Engineering (Southport) Ltd. will be showing " Spryt " Two-Stroke Petrol Engines, for lightweight Motor Cycles, Light Tractors, etc., and as static power units for pumping, lighting, etc. ; the Brockhouse Torque Control Wrench, an instrument for measuring the torque applied to nuts and bolts ; " B.M.B." Light Agricultural Tractors ; " Dapta " Joints, high efficiency universal joints for special applications ; and Metal Building Structures.

Brockhouse Heater Co., Ltd., West Bromwich, are showing a range of industrial heater equipment, including the Brockhouse " V.S. " Type Gas-Fired Steam Boilers for industrial applications, the Brockhouse " V.S." Type Gas Fired Hot-Water Boilers for industrial applications, and " Gyral " oil Burners for light or heavy oils.

Warwick Rim & Sectioning Co., Ltd., West Bromwich, will be showing Cold Rolled Sections for Motor, Building and Aircraft Industries, etc., in ferrous and non-ferrous metals. One of the specialities is sections in stainless steel. Venduraform, another product on view, has as its basis " Vendura," a laminated material consisting of aluminium sheet with a real wood veneer in a variety of grains. This material is rolled into a variety of section shapes.

David Brown & Sons (Huddersfield) Ltd. will present, at Stand D.138, Birmingham, an impressive picture of the activities of their companies at Huddersfield, London, Penistone, Coventry and Salford. Park Works is showing examples of the famous range of Radicon worm reducers, together with bevel and helical units, automobile gearboxes, steering and differential units, worm and spiral bevel gears, hypoids, gear pumps, industrial gears and a Research disc testing machine for materials and lubricants.

The **David Brown Foundries Company** has sent an interesting lot of carbon steel, stainless steel, high-tensile and heat-resisting alloy steel castings for aircraft,

Fig. 3

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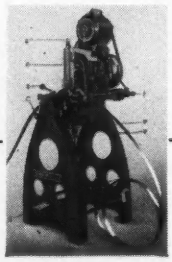
"It is impossible . . ." said Mr. Turner, idly squaring a circle on his blotting pad, ". . . . to keep in constant touch with all our business friends. Our Sales Flags pepper the world . . . trained flag-stickers work day and night to keep up with our order books. But, at the British Industries Fair we can meet these friends face to face. Come and see us and tell us the one about the Englishman, the Irishman and the Scotsman . . . or if you prefer it, about the Zulu, the Maori, and the Venezuelan! It's all one to us . . . . we've heard it, anyway!"



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transport, marine, oilfields, refinery and industrial purposes, and Taurus bronze sand and centrifugal castings. Centrepiece of their section is a demonstration of the use of X-rays in foundry inspections.

The **David Brown Tool Company** shows the recently introduced universal worm gear tester, shown in Fig. 3, the Topograph surface roughness measuring instrument, gear comparators, floating reamers, straight and spiral bevel cutters, spur and helical cutters, wormwheel, spur, helical, spline and serration hobs, and worm milling cutters.

David Brown Gears (London) Ltd. make a feature of Radicon worm reducers for small and fractional horse powers, and low pressure gear pumps. Also on view is a marine reverse and reverse/reduction gear unit.

Heavy iron and acid open hearth steel castings, rolls and gear units typify the products of **David Brown-Jackson, Ltd.,** and there are also examples of machine-cut spur, helical and bevel gears. Also represented are the **Coventry Gear Company** and the **Keighley Gear Company.**

The B.T.R./Silvertown Group, consisting of the British Tyre & Rubber Company, Ltd. (B.T.R.); The India Rubber, Gutta Percha & Telegraph Works Company, Ltd. (The Silvertown Company); James Lyne Hancock, Ltd.; Morgan Ebonite Company, Ltd.; The Palmer Tyre, Ltd.; etc., will be showing at Stand D.615, Birmingham, lengths of Conveyor and Transmission Belting, impressively connected to enlarged photographs of interesting applications. The B.T.R. Conveyor belt display illustrates the movement of grain and B.T.R. transmission belts are shown driving the modern machines which grind flour. Another prominent display will show a typical installation of Silvertown Ebonite pipes and fittings, through which liquid is visibly circulated through gauge glasses and transparent sections. Associated with this feature are interesting examples of ebonite mouldings and hand-made units. Hose—another outstanding product of the B.T.R. group—is represented by a pictorial presentation of the familiar pneumatic pick in road-reconstruction service, as well as by lengths of hand-built hoses up to 15 in. inside diameter for the suction and discharge of difficult materials such as sand, gravel, oil, etc. The moving conveyor belt which has always been a centre of attraction on B.T.R./Silvertown stands will again be in operation, showing groups of small rubber and ebonite articles which exemplify the great variety of applications for which the ten factories of the Group cater. Cutless bearings for motor boats, high-speed craft of all kinds and ocean-going vessels are displayed in an appropriate setting. Flexible pipes for high-pressure oil-feed lines and hydraulic systems will also be in evidence.

W. Canning & Co., Ltd., Birmingham, will be exhibiting at Stand D.207/106, Birmingham, a new type barrel for chrome plating, shown herewith in Fig. 4, eliminating the lengthy process of wiring up articles which are of suitable shape and size for barrelling. The improved motor-driven "Major" and "Minor" Plating Barrels will also be exhibited, and an improved electrically heated Centrifugal Dryer will be seen in operation. Among the exhibits are included Idler Backstands of both the floor and bench types, and a Centreless Polishing Machine for small articles of almost any shape. There will also be shown Automatic Polishing Apparatus for dealing with a considerable range of articles, including lamp bodies, reflectors, radiator caps, etc., and a Three-Spindle Polishing Machine for continuous automatic polishing of light cylindrical articles, as well as a semi-automatic machine for polishing dome-shaped articles of up to 4 in. diam.

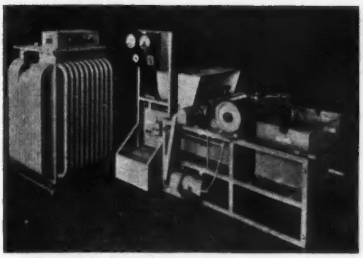

Fig. 4.

with an output of up to 200 articles per hour dependent upon size and finish required. Other exhibits include Canning A.C. Polishing Motors, Plating Dynamos, Canning-Westalite Rectifiers, new "Meteor" type Resistance boards, polishing bobs, mops, brushes, wheels, compositions, plating salts, plating and dipping requisites and lacquers. A collection of articles illustrating the many processes and finishes in plating and polishing will also be displayed.

George Cohen, Sons & Co., Ltd., and other Companies in the 600 Group, will have numerous exhibits at Birmingham. Among these exhibits are :—

The Jones 'KL 100' Shunting Crane, the largest in the range, with a lift up to 5 tons; the Jones 'KL 44' of robust construction and designed to stand up to an immense amount of rough handling; the Jones 'KL 44' Lorry Mounted Crane, capable of travelling, at low speed, with the full working load; the Jones 'KL 22', virtually a smaller model of the 'KL 44' and having a wide variety of uses in many industries; the Jones 'KL 15', of compact design and ideal for use on sites where working space is restricted. Jones Cranes are manufactured by **K. & L. Steelfounders and Engineers, Ltd.,** and marketed in the U.K. by George Cohen, Sons & Co., Ltd.

Machine Tools exhibited include the Coborn-Wadley Type D.E.P.S. 24 Universal Punching, Shearing, Cropping and Notching Machine; the Coborn Type No. 20 Open Front Inclinable Press; the Coborn 42 in. Gap Hand-operated Panel Wheeling and Raising Machine.

Among Woodworking Machines are the new Metalclad 30 in. and 36 in. Bandsaws, designed for high speed work with maximum safety; the Metalclad 16 in. by 19 in. Combined Over and Under Planer and Thicknesser, designed for planing, rebating and bevelling by hand feed, and for thicknessing and moulding by power feed; the new Metalclad 12 in. Planing, Jointing, Rebating and Moulding Machine, designed for ease of operation; the new Metalclad 8 in. Bandsander; and the Metalclad 21 in. Type 'AA' Circular Saw Bench. These Machines are manufactured by **Metalclad, Ltd.**

Also shown are the "Browett-Coborn" 3 h.p. and 6 h.p. petrol and petrol/paraffin air-cooled engines, manufactured by **Browett Lindley, Ltd.**

Steel castings and "Coborn" cast steel anvils will also be exhibited, including the 14 lb. "Handyman" designed for the home craftsman. These are manufactured by **K. & L. Steelfounders and Engineers, Ltd.**

'Sintrex' Iron Powders—Electrolytic Iron Powders for Powder Metallurgy, and Grey Cast Iron Powders for Chemical Reduction and Floor Hardening, marketed by George Cohen, Sons & Co., Ltd., will also be displayed.

Finally, the new 12-ton self-contained hand-operated Hydraulic Moulding Press, and the new 50-ton Coborn Hydraulic Press, marketed by George Cohen, Sons & Co., Ltd., will be seen on the Stand.

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ANNOUNCING NEW

ARGONARC

WELDING EQUIPMENT

This is the Argonarc Welding Torch in a new, streamlined form — re-designed to make Argonarc Welding simpler and even more efficient. The principle of this process is that Argon is passed through the Torch at low pressure. This inert gas acts as a shroud, protecting welds from contamination by the atmosphere. There is no danger of corrosive after-effects in light metal alloys, as no fluxes need be used. The source of heat, a tungsten arc, is small and concentrated; there is therefore little or no distortion of the parent metal.

The B.O.C Sales Technical Service Department will be glad to give you details of this method of welding.

VERSATILE
Suitable for welding aluminium, magnesium copper, nickel and their alloys also stainless steel

FLUXLESS
No fluxes required
No flux corrosion
No flux removal

SIMPLE
Minimum distortion
Minimum weld finishing
Minimum operating fatigue

EFFICIENT
High quality welds
Speedy operation
Compact and portable equipment

THE BRITISH OXYGEN CO LTD
London and Branches

Cinema-Television Limited, London, are showing at Olympia, London, the Cintel industrial electronic batching counter, a new electronic instrument for industrial control. The instrument will separate objects fed from a bulk supply into batches of any required number up to 1024. It will be shown at the Fair batching buttons. The batching counter is operated photoelectrically, each button breaking a light beam falling on a photo-cell. The counter also keeps a record of the total number of batches which have been handled. Obvious applications of the instrument are in batching ball-bearings, screws, pins, fasteners, etc. This firm will also be exhibiting a new electronic device for the detection of metal inclusions in chemicals, plastics, textiles and foodstuffs, etc. The instrument, the Cintel Industrial Electronic Metal Detector, shown in Fig. 5 in use for biscuit inspection, is in great demand where protection is required for both manufacturer and consumer against "tramp" metal—small metal particles concealed in non-metallic material. In

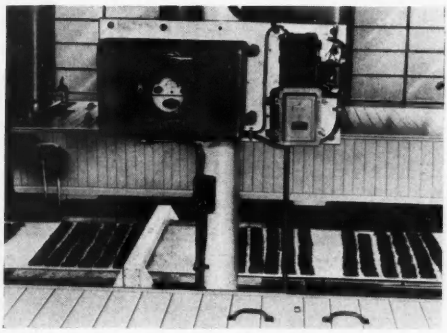


Fig. 5

addition, the Cintel Mutual Inductance Bridge will be shown. Cinema-Television Ltd. are also exhibiting the Cintel Wide Range Capacity Bridge for the measurement of input capacitance of electrostatic cathode ray tubes, etc., also their pipe and cable tracing equipment

Fig. 6

(Type 2) comprising the Metal Detection equipment together with an oscillator. This combined instrument can be used for tracing the course of buried pipes and cables for very great distances. A range of Cintel oscilloscopes, including a demonstration oscilloscope, laboratory oscilloscope and universal oscilloscope, the latter being shown in Fig. 6, will also be on view.

Crompton Parkinson Ltd., London, are demonstrating at Stand C.609, Birmingham, their Nelson Stud Welding Equipment. This system is an electric arc process for fixing ferrous studs, pins and similar items at the rate of dozens per hour—much faster than other methods of fixing. In certain circumstances 14 studs can be welded on in the time taken to drill and tap for one screwed stud.

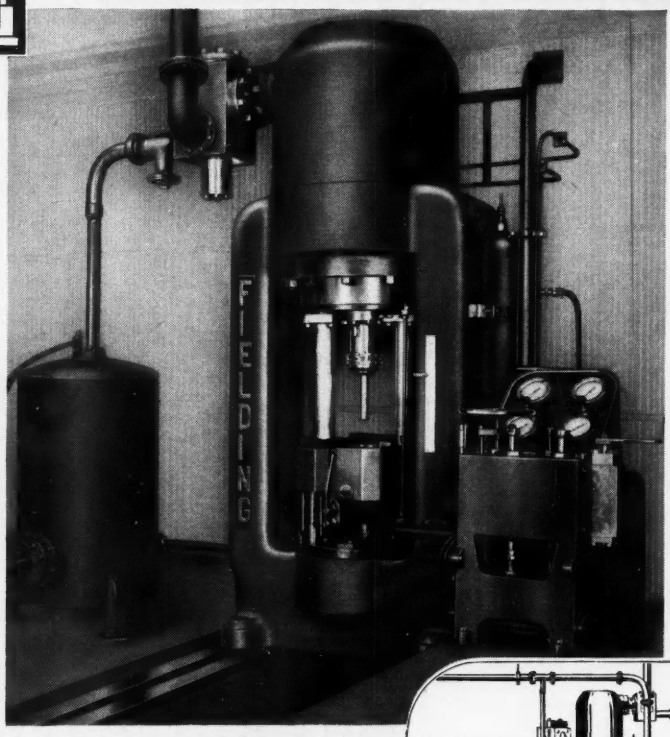
Nelson equipment is designed for use by semi-skilled labour, is portable, built to withstand rough handling and outdoor service. The gun by which the process is carried out welds studs and pins from 10 s.w.g. to $\frac{3}{4}$ in. Only 5 lbs. in weight, and easily held and operated in any position, it is the right tool for confined spaces. For quantity production the gun can be used as a hand tool or mounted in a fixture for repetition work. A number of guns can be mounted in a fixture for repetition work. A number of guns can be mounted together for multiple stud welding. Electricity is supplied from a D.C. welding generator at about 60-90 volts. Crompton Parkinson will also be exhibiting a range of motors and generators with interesting features, including their 5 h.p. Screen-Protected Squirrel-Cage Induction Motor, the 5 h.p. "Klosd" Squirrel-Cage Induction Motor, the 5 kW. D.C. Generator, the Crompton "Minor" Motor, a $\frac{1}{4}$ h.p. Type SPB Capacitor-Start Induction-Run Motor, and their Railway Motor Type LT111, designed for the new surface stock of the London Transport Executive. Their ALA.1. Switchgear Unit will also be shown. This class of switchgear has been developed to have small dimensions, to minimize and simplify maintenance, facilitate installation and ensure safe and reliable service. Crompton Parkinson will also be showing their 25 kVA 3-phase Pole-Mounting Transformer, a typical outdoor unit for rural supply.

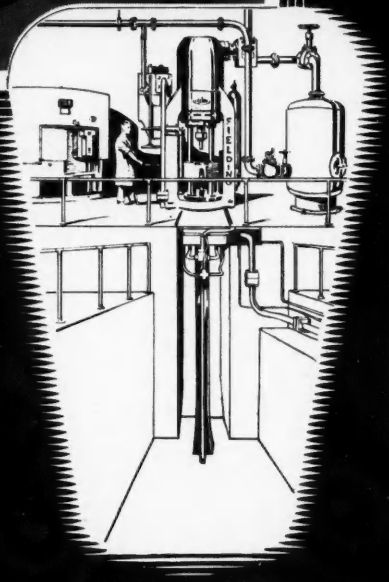
Eccles (Birmingham) Ltd., will include among their exhibits, at Stand D.628, Birmingham, new and improved models of their 4-wheeled General Purpose Truck to carry loads up to 1 and 2 tons. A choice of bodies is given to suit all trades. These models are particularly suitable for the export market. A Bobbing Truck for Textile Mills, Lifting Trucks, Stillages, and scale models of special Trucks for individual trades will also be shown.

F. J. Edwards Limited, London, showing at Stand D/411, Birmingham, list the following BESCO exhibits :—

Model 1A Open Fronted Vertical Section Bending Roller, shown in Fig. 7.
Model 72/36 Production Press Brake, capacity 36 tons, shown in Fig. 8.
Multiple Turret Punch.
Model E.B.4. Eccentric Punching Press.
Model 280 Trimming and Beading Machine.
Model KS Universal Punching, Shearing, Section Cropping and Notching Machine.
Model 412 All Steel Folding Machine.
Model 318 All Steel Folding Machine.
No. W445 Combination Set for Shearing, Notching & Bending angle sections in the manufacture of frames, etc.
Model LSN 1 Hand Lever Operated Angle Iron Shearing and Notching Machine.

In addition to the above there will be a large selection of Sheet Metal Working Machines, including Folding Machines, Guillotines, Hand and Power Presses, Wheel-





FIELDING VERTICAL EXTRUSION PRESSES

A complete range of "Fielding" Vertical Extrusion Presses are available for the direct and indirect production of non-ferrous and light alloy rods, tubes, solid sections, profiles, etc. With the extra long guides on the main ram and with perfect maintenance of container alignment, the production of tubes having very high concentricity can be obtained with this type of plant.

Quotations and designs submitted for complete plant to suit customers requirements.

FIELDING & PLATT LTD

ENGINEERS ATLAS WORKS

GLOUCESTER • ENGLAND

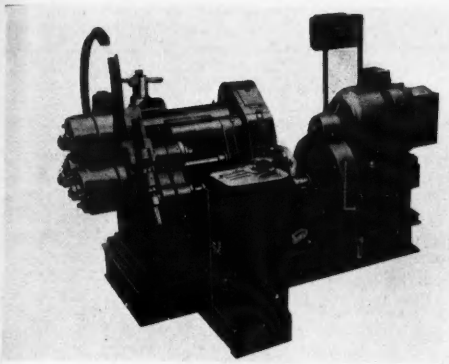


Fig. 7

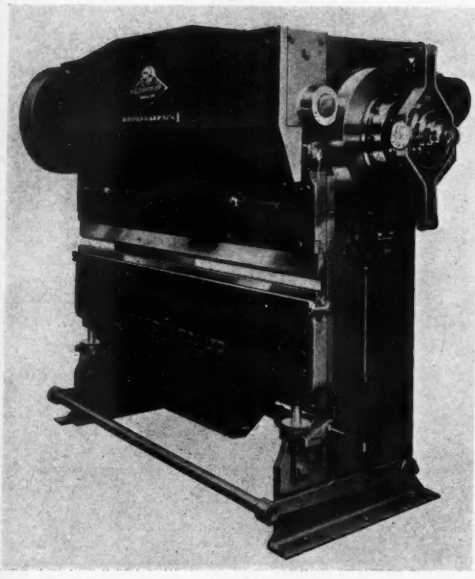


Fig. 8

ing and Raising Machines, Swaging, Wiring and Jennying Machines, Bending Rollers, Bar Benders, Circle Cutters, Throatless Shears, Hand Lever Shears and Rotary Shears, Panel Beaters' Heads and equipments.

W. Edwards & Co. (London) Ltd. will be exhibiting Oil Diffusion Pumps. This firm can now supply a wide range of pumps, operating on Silicone, Apiezon or other high performance oils, together with mercury pumps having speeds ranging from 10 to 10,000 litres per second. Also exhibited will be Rotary Vacuum Pumps. The range of Speedivac high vacuum rotary pumps has been extended by the inclusion of three new models. The two-stage pump model 2S20 has been produced to meet the need for a high vacuum pump for general use in educational, research and industrial laboratories, and also to satisfy the exacting requirements of industrial users on continuous work when a large capacity pump is not essential. With the introduction of these models, the Speedivac series of rotary pumps now covers most possible applications from simple laboratory experiments, to large scale industrial processes. Outstanding features common to all the Speedivac Pumps are the minimum weight and dimensions, small oil capacity, high pumping speed, quiet running and attractive finish. Vacuum coating plant will also be shown. Two of the latest units are the models 12E and 6E evaporation plants, having work chambers of 12 and 6 in. diameter respectively. The specifications are arranged to give equipment ranging from basic pumping units, to complete units offering the facilities of larger industrial models, but on a reduced scale. Among the exhibits will also be included high vacuum gauges, a new vacuum controller and an electronic microammeter.

Electro Methods Ltd., London, are exhibiting at Birmingham a new electronic timer suitable for all applications where high accuracy in repetitive circuit timing is essential. Time range is from $\frac{1}{4}$ to 60 seconds adjustable smoothly on one single control. This timer is for use for all industrial applications requiring precise time control, as for example, process control, lithography, blueprinting, photostating, HF welding, HF processes, drying ovens, mixers, heat treating, plating, induction furnaces, industrial ovens, machine tools, plastic moulding, production control, X-Ray exposures, photography, electrical testing, impulsing, flashing, and continuous cycling. The firm will also be showing a range of Electro-Magnetic Relays, including the Miniature Polarised Relay Type MIN, Instrument controlled or Anode circuit Relay Type ICR, Heavy Duty Relay Type H15, Self-locking Time Delay Relay with automatic delayed break Type STA, Impulse or 2-step Relay Type TSR, Time Delay Relay, Delayed make, ZERO recycling time, Type TDRO, Power Controller Type PC1, Sensitive Aircraft Protection Relay, and a new Miniature Polarized Relay.

The Butcher-Black & Decker Earth Protection Scheme will also be on view. Developed primarily for use with portable electric tools these units are now used in general laboratory circuits for the following reasons :—reduced fire risk, reduced risk of receiving shocks, great ease of testing.

Elliott Brothers (London) Ltd., will be exhibiting at Stand D.503, Birmingham. The main feature of the Stand will be five panels of flush-type industrial indicating and recording instruments, representative of the wide range of equipment for which Elliott Brothers are world famous. These panels will contain the new Elliott Potentiometer Recorder with magnetic inverter, and the new Elliott 3-term Pneumatic Controller, Indicating and Recording Flowmeters, Electrical Measuring Instruments including K.V.A. Recorder and Frequency Recorder, CO_2 and $CO + H_2$ Indicators and 6 Point Recorder (for boiler flue gas analysis), Relative Humidity and Temperature Indicators and 2 Point Recorder.

A most convincing demonstration of the accuracy and response of the well-known Elliott system of remote indication and control will be given by a small transmitter, operated by a knob, coupled to a 33 in. indicator above the Stand. A special exhibit of equipment will show the application of this system to gas distribution.

A 12 in. flush voltmeter and a 12 in. frequency indicator will show mains voltage and frequency.

Pyrometers shown will include an Optical Pyrometer outfit with separate battery in leather case with sling. (Temp. range 800-1400° C and 1200-2200° C), a Portable Total Radiation Pyrometer equipment for furnace temperature measurement, a Portable Thermo-Couple Potentiometer, and a representative range of Thermo-Couple Pyrometer Stems. A Portable Dynamometer Recording Voltmeter, with multi-speed clock, will record mains voltage.

Examples of applications of Elliott magnetic amplifiers demonstrated on the Stand are the photo-electric counter, automatic lighting controller for street lighting systems, thermo-couple amplifier and a servo amplifier.

MODERN

OUR PRODUCTS ARE

$\frac{7}{8}$'' AUTOMATIC

$1\frac{1}{4}$'' CAPSTAN

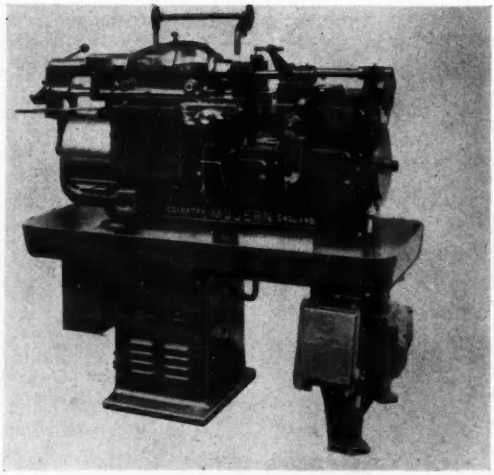
$\frac{5}{8}$'' CAPSTAN

UNIVERSAL OIL GROOVING MACHINE

WESTON SYPHON PUMPS

3 WAY TAPPER

SPECIAL PURPOSE MACHINES



MODERN 1¼" BAR AUTOMATIC

WE NOT ONLY MANUFACTURE MACHINE TOOLS BUT ARE ALSO THE LARGEST STOCKIST OF USED TOOLS IN THE COUNTRY.

OUR PRESENT STOCK IS 2300 FIRST CLASS MACHINE TOOLS.

A rigid compact machine occupying a small area relative to the bar capacity. A standard motor is housed in the cabinet leg, the drive being transmitted by VEE Belts through spiral gears to the headstock.

MODERN MACHINE TOOLS

LIMITED

MANAGING DIRECTOR - - HARRY WESTON

MAUDSLAY ROAD

COVENTRY

TEL.: 2132-6 GRAMS: MODERN

E.M.I. Factories Ltd., Hayes, Middx., will be showing at Stand No. C.516, Birmingham, a wide range of products, indicating some of the ever increasing applications of electronic processes in industry. Working demonstrations will show the great diversity of E.M.I. High Frequency Heating Equipments, all of which are readily adaptable to a wide selection of heating applications. In addition, the highly successful E.M.I. Magnetic Tape Recording will be exhibited. Some brief details of the products and demonstrations that will be seen on the E.M.I. Stand are as follows :

Model EH10A. This Induction Type Heater has an output of 1kW and is especially suitable for the rapid and efficient soldering, brazing and surface hardening of small metal parts, and for heating the metal in the bonding of metal to fabric joins using a thermo-plastic glue.

Model RFH/1. A medium-sized dielectric heater giving 1 kW of high frequency power. Primarily applicable to the pre-heating of plastics before moulding.

Model DHE. For applications where only small power (450 watts) output is required, this H.F. dielectric heater is invaluable.

Model DH35. 3½ kW of H.F. power is the output of this dielectric heater, suitable for varied applications.

Model EH35. An induction type heater giving an output of 3½ kW, model EH35 is eminently suitable for applications of similar type but on a larger scale than those mentioned for EH10A.

Model BTR/1. This high fidelity magnetic tape recorder provides recordings of over 20 minutes duration on one reel of "Emitape." Recordings of any required length can be obtained by the use of two such machines.

Numerous accessories for H.F. Heaters and Tape Recorders will also be exhibited. A special method of heating and soldering small metal parts will be shown by means of two model EH10A's and a special turntable applicator making for very rapid working.

The curing of curved wooden laminated sections is very successfully carried out by the Model RFH/1 as is shown by a demonstration of this process.

One of the smaller H.F. heaters manufactured by E.M.I. Factories Ltd., model DH4, is shown heating up various types of plastics.

A large eddy current heater model EH35 with a demonstration jig is shown in operation.

Fescol Ltd., London, will be exhibiting on Stand D/742 at Birmingham. In order to emphasise the important part which is being played by the Fescol Process in the re-equipment of Industry, the exhibit will include an outstanding example of a recent application of this nature, namely the treatment of Table Rollers employed on a Hot Mill of the Northern Aluminium Co., Ltd., at Rogerstone, Newport, shown in Fig. 9. These Rollers are used to transport aluminium sheet during processing, and it was found that they became scored in service and also corroded. It was decided, after tests had been made to determine the best treatment, to protect the surfaces in contact by means of the Fescol Process, and this technique has been applied in order to recondition the existing plant, also to the Rollers of a new Mill under construction by Messrs. W. H. A. Robertson of Bedford. The Rollers are approximately 10 ft. long overall and the conical friction surfaces are protected from the effects of corrosion and abrasion by a deposit of Chromium, thus increasing the life of the plant and improving the product.

A Roll so treated, with an illustration of the actual Mill on which these Rolls are employed, will form the central feature of the exhibit.

There will also be on display a Morgoil Bearing supplied by Messrs. Davy and United Engineering

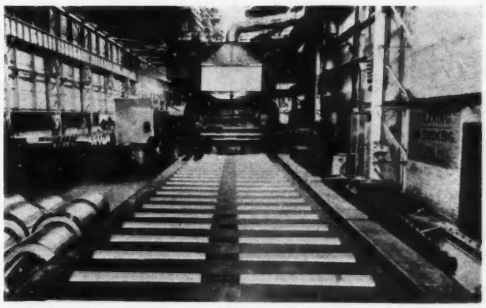


Fig. 9

Co., Ltd., as used on Rolling Mill Plant, the frictional surface of which has been Fescol-ised in Chromium, to reduce friction and to withstand wear. An example of a pair of Planishing Rolls, the surfaces of which have been deposited in Chromium, will also be on show. The former, when finished to a mirror surface, has been found to give excellent results in the production of non-ferrous sheet. The Chromium provides resistance to atmospheric corrosion, so obviating the necessity of greasing the surface when the plant is not in use. Tracking marks are eliminated and a high degree of finish is assured.

The protection of Turbine Blades against corrosion is carried out on a large scale by the Company. Specimen Blades so deposited will be shown by kind permission of the manufacturers.

Amongst other exhibits will be Crankshafts, both large and small, which have been restored to size after wear, and also a number of components of medium and small size deposited in Chromium and Nickel, to illustrate the variety of work carried out by the Company.

Foster, Yates & Thom Ltd., Blackburn, will be exhibiting at Birmingham yet another addition to the Company's range of Hydraulic Presses of the "Lancastrian" Series. This time, it is a Plastic Moulding Press, which is capable of producing Plastic articles in considerable quantities at each mould. A complete set of instruments is fitted at a convenient height in full view of the operator, and cover every indication required for the complete control of the Press under all working conditions. The Press is supplied, complete with all starting equipment, as an entirely self-contained unit, and only requires connection to a suitable power supply.

The firm are also exhibiting their "D.P." Mixers which have been specially produced to meet the increasing demand for a machine for mixing ingredients having widely differing specific gravities. They have an exceptionally wide range of application, and are in use, both at home and abroad, in a variety of mixing processes, such as the mixing of Chemicals, Brake-Lining Materials and Colour Pigments. Compact and easily transportable, the mixer is a fully self-contained unit, supplied complete with all electrical equipment built in and fully enclosed, yet easily accessible for maintenance purposes. The "D.P." series is offered in a range of sizes from a Laboratory size model to a machine having a drum of 20 cu. ft. capacity.

The Glacier Metal Co., Ltd., Alperton, Wembley, will be exhibiting a comprehensive range of plain bearings, bushes, bearing bronzes, whitemetals, etc., covering most engineering needs and falling under the following headings :—

Steel backed thin wall and thick wall whitemetal and copper lead lined bearings.

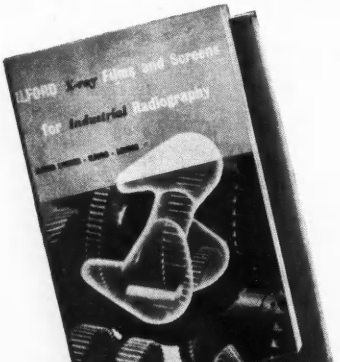
Bronze backed whitemetal lined and solid bronze unlined bearings and bushes.

seeing is believing

but only when the recording materials are of the highest dependability. For this reason the most rigorous testing is applied to all Ilford Industrial X-ray Films to ensure reliable and consistent performance.

The three grades of Ilford Industrial X-ray Film provide for every requirement of industrial radiography and are as perfect as laboratory research, skilful technique and modern manufacturing methods can make them.

Send for the Ilford book—"Ilford X-ray Films and Screens for Industrial Radiography." It has been written specially for industrial radiographers and contains much information to assist them in their work.

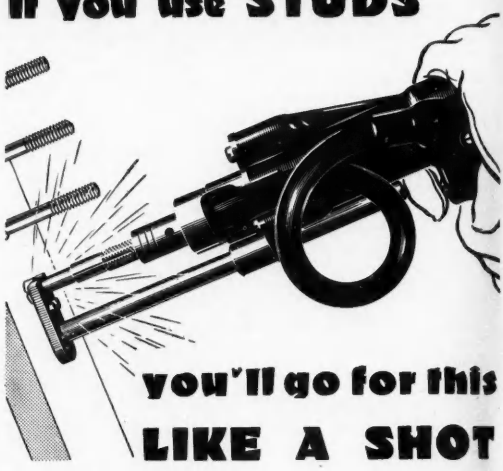


ILFORD

serves the industrial radiographer

ILFORD LIMITED · ILFORD · LONDON

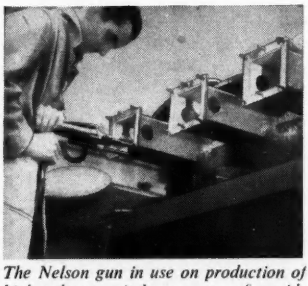
If you use STUDS



you'll go for this LIKE A SHOT

Take a look at industry's most versatile fixing tool—the Nelson stud welding gun. It welds studs to steel 14 times faster than the old method of drilling and tapping. It weighs only 5 lbs., is easy to operate and absolutely safe. It makes every weld neat, uniform and immensely strong, because from the touch of the trigger the welding operation is completely automatic.

The wide range of Nelson fastener studs and the versatility of the gun enable you to use studs for jobs where studs were never used before—wherever you need to fasten anything to steel. This is why production engineers in more and more industries are going over to Nelson stud welding. Send today for the new Nelson Brochure and learn about this time-saving cost-cutting production technique.



The Nelson gun in use on production of high voltage switchgear—one of a wide variety of applications in electrical manufacture. Nelson studs can be used on oil tanks because the welding does not perforate the parent metal.

NELSON STUD WELDING SERVICE

CROMPTON PARKINSON LIMITED
PLANT DIVISION
CROMPTON HOUSE, ALDWYCH, LONDON W.C.

Tin and lead base whitemetal die castings.

Standard Wrapped Bushes steel backed lead bronze lined in a range of 350 English and Metric sizes—all available ex stock.

Precision finished lead bronze bars machined in the bore and on the outside diameter to assembly tolerances for bushes, thrust washers, etc.

Standard phosphor bronze bars machined on the outside diameter for bushes, thrust washers, etc.

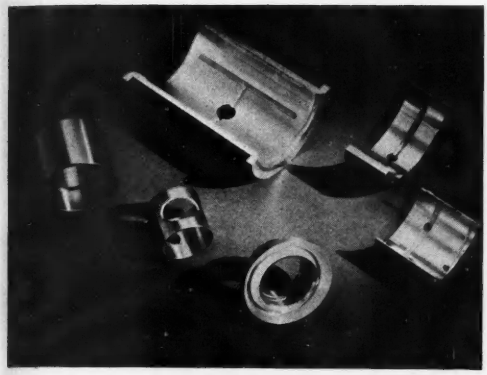


Fig. 10

The Company's standard products include a range of strip type steel backed whitemetal lined thin wall half bearings as used in most automobile engines today, and standard bushes steel backed lead bronze lined which are offered in 350 sizes for immediate delivery. Examples of the range of products exhibited are shown in Fig. 10.

The Goodyear Tyre & Rubber Company (Gt. Britain) Ltd. will be showing a full range of industrial rubber products, including conveyor belting, V-belting, transmission belting, cord belting and various types of industrial hose. Visitors will also be able to see, in miniature, one of this Company's great industrial achievements in action. It is a working model of the world's record conveyor belt lift at the famous Tennessee Iron and Steel Installation at which coal is raised 715 ft. on a single-flight Goodyear conveyor. Another interesting feature, the Goodyear On-Site Conveyor Belt Service Unit, has now been fitted with a flame-proof vulcanizer, which enables it to be used at all mining installations. In the Goodyear hose department, metal reinforced hoses up to 8 in. diameter are now being produced. This large diameter hose is used for ship-to-ship oil re-fueling at sea, or for dock-side oil transference, while at the other end of the range are hoses capable of similar arduous work on a smaller scale — down to $\frac{3}{4}$ in. diameter — on modern petrol pumps. One of the major factors in the development of hose for the oil and petrol industry has been the use of synthetic rubber. Synthetic, unlike natural rubber, is impervious to the action of oil, and, therefore, permits a much more flexible type of hose to be used than has previously been possible. The very extensive Goodyear hose range, therefore, should prove interesting and has been given special prominence at their Stand.

Hancock & Co. (Engineers) Ltd., Croydon, will be exhibiting at Stand D.739/638, Birmingham, their "U" Arm Profiling Machine, shown here in Fig. 11. This type of machine is made in four sizes for cutting steel up to 8 in. thick. Greater thicknesses can be cut on larger machines. The Tracer Head incorporates five different forms of drive requiring wood, metal or strip templates, or for working direct from a drawing without any template.

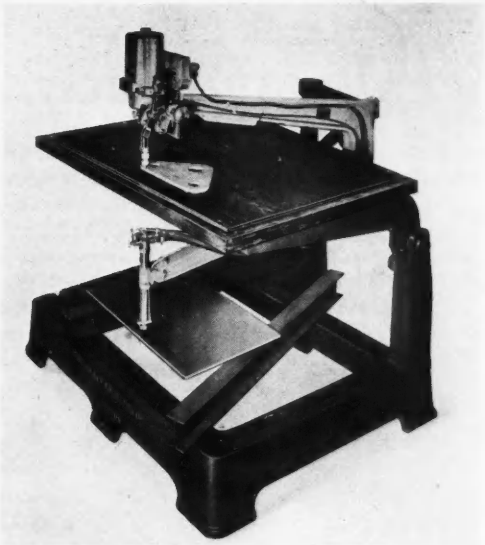


Fig. 11

As an example of speed and precision, 1 in. plate can be cut at a rate of 12 in. or more per minute to an accuracy of $\frac{1}{64}$ in. or less, depending on the size and conditions of the job.

G. A. Harvey & Co. (London) Ltd., will be showing at Stand No. B.329, Birmingham, a wide range of manufactures produced at their extensive Works in Greenwich.

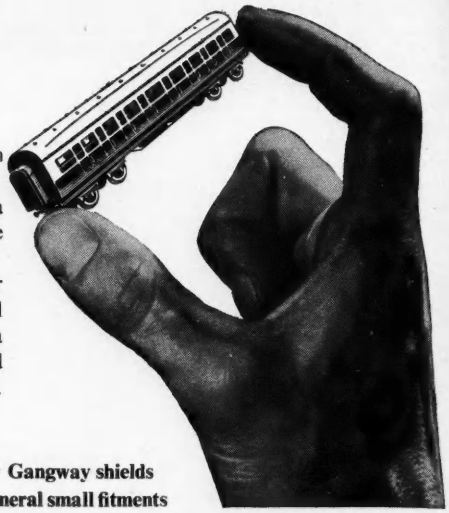
During the past few years this Company has added considerably to their facilities for the fabrication of Steel Plate. They are now able to undertake the manufacture of Pressure Vessels, Autoclaves, Fractionating and Absorption Towers in Steel Plate up to 3 in. in thickness and of any diameter and length. Work of this nature is portrayed to distinct advantage by the use of photographs on their Stand. Components necessary in the fabrication of High Pressure Vessels and Steel Platework generally have for many years occupied the attention of this Company, and they are able to supply for the Trade a complete range of "Harco" "Rotarprest" Ends, Dished and Flanged Ends, Channel, Angle and Flat Bar Rings. An outstanding exhibit in this connection is the display of cold rolled Rings flash butt welded, which are an indication of the type of work produced. The Rolls Messrs. Harveys have recently installed enable them to roll Bars cold up to 16 in. by 6 in. joist and 12 in. by 1 in. flat, to mention only two of the heavy sections they are able to work.

The range of "Harco" Perforated Metals exhibited shows the innumerable patterns available, for all Screening, Grading, cleaning, sorting and filtering requirements.

"Harco" Woven Wire Cloth is displayed in a variety of metals in all meshes and gauges. Of special interest are the "Harco" Special Quality Wire Screens used for vibrators. Wirework is displayed in products suitable for domestic and Industrial needs, amongst which will be noted Machinery Guards, Window Guards, etc.

A range of "Harco" Steel Equipment also will be found on this Stand. Steel Desks and Tables, Filing Cabinets, Cupboards, Shelving and Lockers for Staff and Workpeople, Storage Bins and Racks, are only a few of the items produced by this Company.

Take a railway coach...



and see the many points in its construction where aluminium alloys can be used with increased efficiency and economy.

Our Technical and Development Departments have done a vast amount of research on this subject, and the results are freely available to rolling-stock designers and builders.

Aluminium alloys have equally important uses in many other industries and information about them is at the disposal of all who are interested. The Metals Division of I.C.I. produces a wide range of aluminium alloys in sheet, strip, tubes, extruded rods and sections. Some of them might be useful to *you*. Please tell us your problems.

I.C.I. aluminium alloys are recommended for :—

Structural members · Roofing and panelling · Window frames · Gangway shields Sliding and folding doors · Tubular seating · Luggage racks · General small fitments

'KYNAL' AND 'KYNALCORE' ALUMINIUM ALLOYS

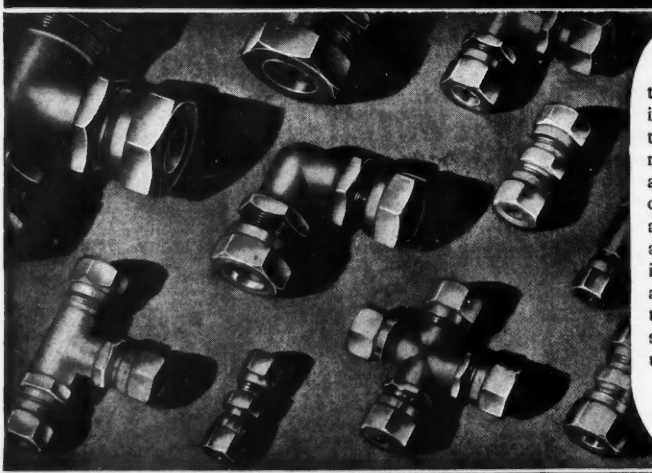
IMPERIAL CHEMICAL INDUSTRIES LTD., LONDON, S.W.1

ICI

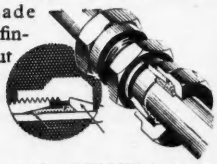
M.155A

ERMETO

JOINTS *can be* BROKEN *and* REMADE *almost* INDEFINITELY



The Ermeto Joint is so designed that when the nut is tightened the sealing ring cuts into the surface of the tube and throws up a collar of displaced metal. The ring itself becomes attached to the tube and because of this Ermeto joints can be broken and re-made almost indefinitely without affecting their pressure tightness.



1 Case hardened ERMETO ring
2 Cuts its own sealing flange
3 As you tighten the locking nut

BRITISH ERMETO CORPORATION LTD.
BEACON WORKS • HARGRAVE ROAD · MAIDENHEAD · BERKS.

Hoover Limited are displaying at Birmingham their range of F.H.P. Electric Motors, an example of which is shown here in Fig. 12. Models to be shown include split phase, capacitor start and 3-phase motors in horsepowers ranging from one sixth to one third—and a special range for refrigeration applications.

Fig. 12.

The Hilger Division of Hilger & Watts Ltd., exhibiting this year at Stand B3, Birmingham, is merged with that of the Watts Division, the stand having been arranged by a group of members of the SCIEX Organisation. The principal exhibits will include the Uvispek Spectrophotometer designed for observing and measuring the ultra-violet and visible absorption spectra of solutions, and other substances, and shown in Fig. 13. Also exhibited will be the Abbe Refractometer, and the new Hilger Small Polarimeter, which departs in many ways from earlier designs, but still maintains the general appearance of a standard polarimeter. The Hilger Division will also be showing their Spekker Absorptiometer and Fluorimeter, as seen in Fig. 14, which has been completely redesigned, except that all the important optical features of the older instrument are retained. Another interesting exhibit will be their new Galvoscale galvanometer. Both the galvanometer and the associated optical system are contained within a metal casing which protects them against dust and damage. The moving scale reflected from the galvanometer is observed in a convenient, shielded, translucent screen, where it is visible even in a well-lighted room. An ingenious, but simple sloping line device in the lower part of the field enables the section on the scale in use to be quickly identified. A newly designed anti-vibration mounting for the galvanometer is incorporated in the device. In addition, there will be shown the Hilger Barfit Wavelength Spectrometer, and the Photo-measuring Micrometer, an accurate linear measuring device.

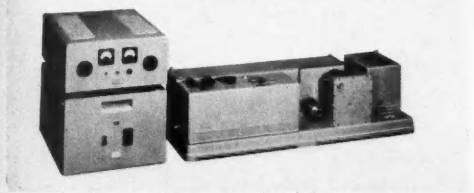


Fig. 13

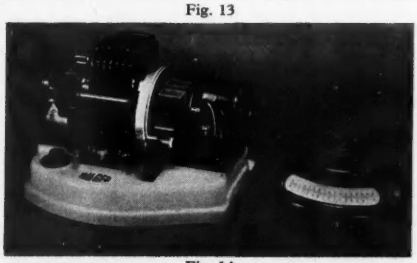


Fig. 14

Hordern, Mason & Edwards Ltd., Birmingham, will be exhibiting at Stand D.500, Birmingham, five various types of Presses, all on production. The No. 2 Rising Table Press which aroused such interest last year will again be demonstrated, together with types No. 13 Double Action, C.28 Double Sided Single Action, L.20 Dial Feed and L.40 Strip Feed. The latter machine, shown here in Fig. 15, is being exhibited for the first time and will be employed at the Fair on the production of "Give Away" Ash Trays. This Press has several unique features and the feed mechanism is protected by a British Patent. It gives a high rate of production and performs the double function of feeding short cut strips as well as feeding from coils, the latter being the conventional method of ordinary Roll Feed Presses.

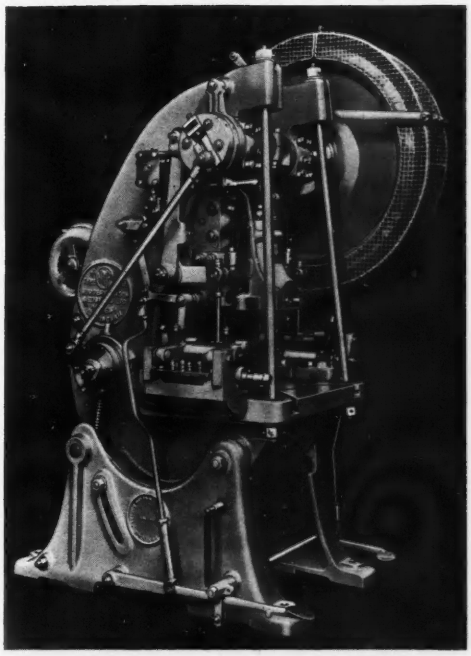
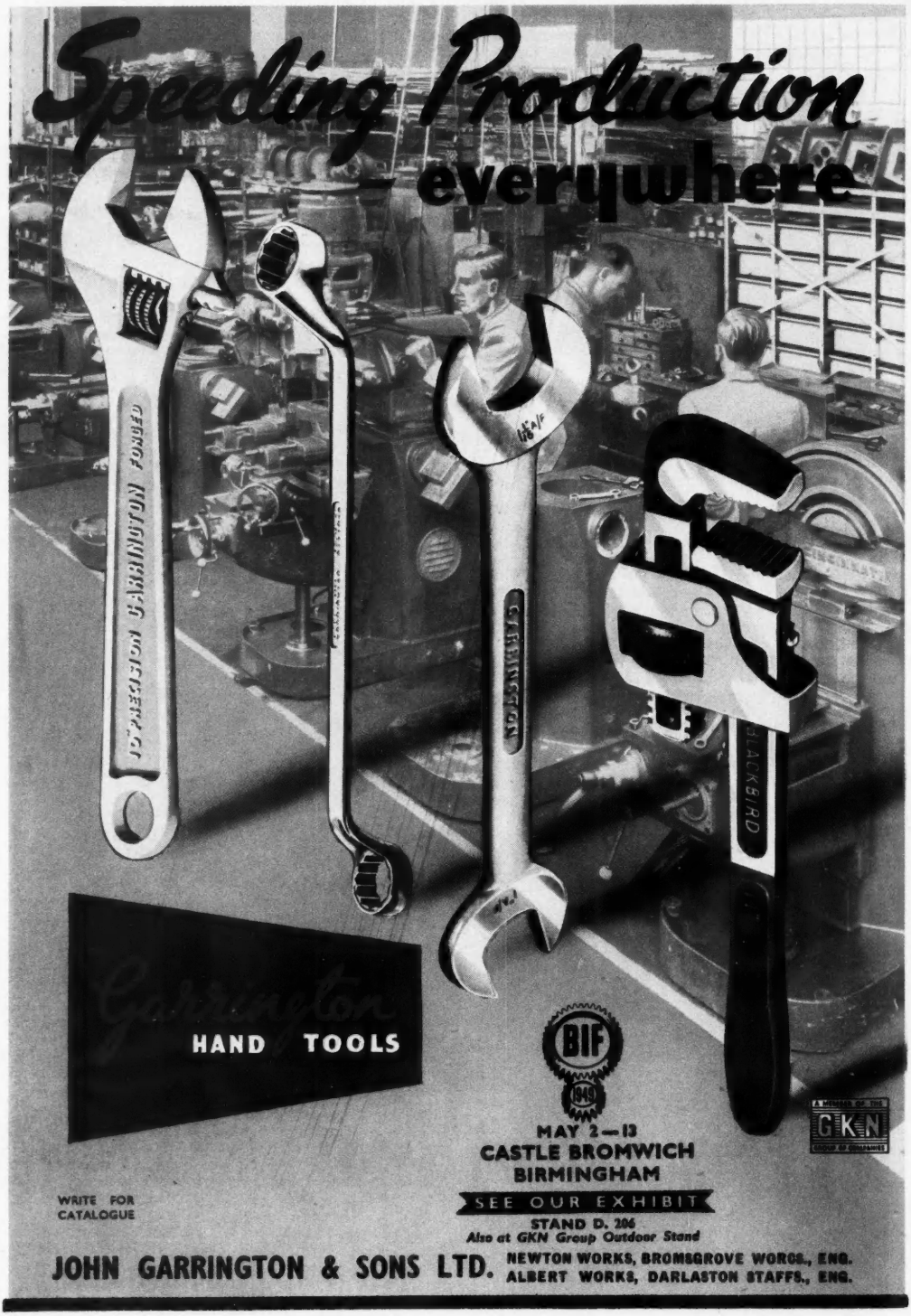


Fig. 15

The General Chemicals Division of Imperial Chemical Industries Ltd. are featuring at Stand D.315/D.212, Birmingham, their Metal Degreasing Service and their Heat-Treatment Service for molten salt baths. Amongst the several metal degreasing plants on view will be an electrically heated bench model for handling delicate instrument parts, a medium-size plant to work on a single-phase A.C. supply, and a totally enclosed continuous plant (with automatic ventilation) for degreasing intricately-shaped articles. All these plants will be installed for normal working on the Stand. In addition to featuring the various Cassel


Speeding Production
everywhere
GARRINGTON
BLACKBIRD
Garrington
HAND TOOLS
BIF
1949
MAY 2—13
CASTLE BROMWICH
BIRMINGHAM
SEE OUR EXHIBIT
STAND D. 206
Also at GKN Group Outdoor Stand
GKN
WRITE FOR
CATALOGUE
JOHN GARRINGTON & SONS LTD.
NEWTON WORKS, BROMSGROVE WORCS., ENG.
ALBERT WORKS, DARLASTON STAFFS., ENG.

Heat Treatment Salts and processes, the exhibits include a selection of standard "Cassel" Salt Bath Furnaces of an unusually wide range of sizes (the largest shown has a pot 72 in. deep). Of particular interest is a totally enclosed automatic carburising furnace.

The Metals Division of Imperial Chemical Industries Ltd. will feature at Stand D.409/308, Birmingham, three main exhibits, dealing with condenser tubes, aluminium alloys and roofing panels. A model representing the inlet end of a condenser will be used to demonstrate some operating conditions which tend to produce failure of condenser tubes through erosion or impingement attack. Sections of tubes which have failed in these conditions will also be displayed. A second exhibit will show how aluminium alloys can be used in coachbuilding to produce vehicles which are strong, light, durable and an economic proposition. Also featured will be an exhibit illustrating the extensive investigation work associated with copper or aluminium alloy faced roofing panels, and with the adhesives for bonding the layers which make up these units. Their behaviour under rapidly varying temperatures will be shown.

Jenks Brothers Ltd., Wolverhampton, will be exhibiting at Stand D.101, Birmingham, their Britool range of Hand Tools such as Bihexagon Ring Wrenches, Socket Spanners for normal or Ratchet operation, also Specialised Wrenches for all branches of engineering production, maintenance and service. These will be available in greatly increased ranges in English, American and Continental Standards of sizes from as small as 0.117 in. across flats hexagon to as large as 3⅛ in. across flats hexagon. These sizes relate to stock items, but in addition, sizes outside this range are made against special demands. Britool exhibits will include for the first time the smallest Ring Wrench in the Fair and probably the smallest made in Europe (available as a stock item). A complete range is available for instrument, aircraft, radio, electrical and other miniature nut turning operations. Among Workshop Service Tools an entirely new fixture for servicing internal combustion engine cylinder heads will be on view. A full range of ratchet operated Refrigerator Wrenches will also be on view, together with Torsion Wrenches, Panel Beaters' Tools and Service Socket Sets.

Marconi Instruments Ltd., St. Albans, Herts, will be showing at Stands C6 and C21, Olympia, London, a wide range of equipment. On Stand C21, will be seen their Circuit Magnification Meter TF886; Transmitter Output Meter TF912; Standard Signal Generator TF867; Video Oscillator TF885 (shown in Fig. 16); R.F. Test Set (X Band) TF890; Heterodyne Frequency Meter TF897; F.M. Receiver Tester TF913, Universal Bridge TF868, H.F. Field Intensity Meter TF930; Airborne Equipment Test Rack OA 216;

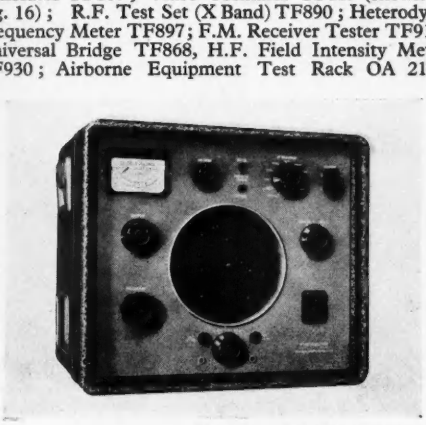


Fig. 16

Precision Frequency Measuring Equipment TME2; Level Recorder TF946.

The Measurtest Range also shown will comprise their Valve Voltohmmeter TF887; Receiver Tester TF888; Valve Millivoltmeter TF899.

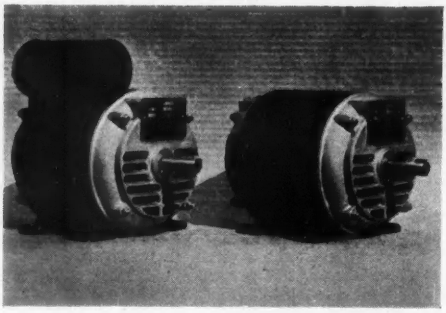
There will also be shown a range of industrial instruments, comprising a pH Meter (Direct Reading) TF889; pH Meter TF511D, battery electrometer for the precise laboratory measurement of pH, and other mV potentials developed by electro-chemical action; Moisture Meter TF933, a portable instrument designed for the rapid and accurate estimation of the moisture content of a wide range of hygroscopic substances—particularly cereals and tobacco, and shown in Fig. 17;

Fig. 17

Moisture-in-Timber Meter TF874 for the determination of moisture content in timber and synthetic boards; Conductance Meter TF721B, a portable, self-contained battery instrument calibrated in mhos, and covering the remarkable range equivalent to a resistance of 1 megohm to 1 million megohms without the use of external batteries; Varistrobe TF906, a mains operated stroboscope for the observation of rotating reciprocating or vibrating mechanisms; Thickness Meter TF884, non-destructive method of determining the thickness of plating or paint deposits on a ferrous base; Electronic Counter TF922, for counting a million periodic or random impulses at rates up to a hundred thousand per second, or for the measurement of time intervals up to ten seconds in steps of 10 micro-seconds. Quantities or time intervals are displayed as illuminated numbers on a six decade scale; Conductivity Recorder TF863. In conjunction with a suitable conductivity cell of known constant (available as an accessory) the instrument determines and records electrolytic conductivity. It has a coverage of 0-1 millimho which is obtainable over a variety of ranges.

Metropolitan-Vickers Electrical Co., Ltd., are exhibiting at Stand C.510, Birmingham, their "Metrolock" Control Cubicle. "Metrolock" is a trade name of this Company for a variety of electronic control equipments. The exhibit is an equipment, arranged for demonstration, of a type developed to give accurate control of the speed relationship of a number of motors working together. The control is applied to two motors, the base speeds of which are controlled together by means of a Ward-Leonard generator supplying both motors.

The speed-ratio of the motors may be varied, and the selected speed ratio is maintained, irrespective of load, etc., within a fraction of 1 per cent. Following on extensive operating experience with earlier models of Metrovick electron microscopes, the Metropolitan-Vickers Electrical Co., Ltd., has now designed and put into normal production the Type "EM3" Electron Microscope which will be exhibited at their Stand. This microscope has a number of interesting features, special care having been taken in designing it to make



ELECTRIC MOTORS (¼ H.P. AND ⅓ H.P.)

A.C. ALL VOLTAGES.

Designed for the best possible performance under all conditions—only first class materials used in manufacture. Suitable for small machine tools, refrigerators, etc.

EX STOCK DELIVERY.

(F.o.b., c.i.f. prices on request to any part of the world.)

TROPICALISED.

ENQUIRIES INVITED FOR

★ **MOTORS OF LARGER H.P.**

★ **CLUTCHES FOR ¼ H.P. AND ⅓ H.P. MOTORS.**

★ **STATOR AND ROTOR UNITS WHICH CAN BE SUPPLIED SEPARATELY TO CUSTOMERS' REQUIREMENTS. MANUFACTURERS ARE INVITED TO TAKE ADVANTAGE OF THIS UNIQUE OFFER.**

RING MOTORS LTD.

Regd. Office: Midland Works, John Street, Shipley. Yorkshire.
WORKS: CLARENCE ROAD, LONSIGHT, MANCHESTER, 13. (Phone: RUSHOLME 3903.)
London Sales: Deakin Partners, 16 Copthall Gardens, Twickenham, Middlesex.

Can you afford to go on using "specials" to your own designs when mass produced standards like these are available ex stock at lower prices?

350 stock sizes: steel backed, lead bronze lined.

THE GLACIER METAL CO. LTD.,
ALPERTON, MIDDLESEX, ENGLAND. Telephone: PERivale 4271. Telegrams: BEAUCOUP, PHONE, LONDON.

the work of servicing as simple as possible.

One of the latest manufacturing processes is that of high-vacuum coating by which a thin film of readily evaporated metal is deposited on a selected base material, e.g., glass, plastic or paper. This process is shown in operation with a Metrovac twin-tank type high-vacuum coating plant. The vacuum pumping equipment included with the plant consists of a Metrovac Type 063B oil-diffusion pump for each tank, together with a single rotary pump to back either of the diffusion pumps. All vacuum valves, except the air inlet valves on the tank doors, are electro-pneumatically operated and are controlled by Metrovac Type PTI Pirani vacuum relays.

A trolley bus cab control will also be exhibited, consisting of a working demonstration of the latest type of trolleybus combined controller and switch-group arranged for cab mounting.

Mono Pumps, Ltd., London, will be exhibiting at Stand D.716, Birmingham, the positive rotary self-priming Mono Pump. The nature of its construction lends itself to an immense flexibility of application to modern industrial practice and a considerable number of types have been developed to deal with a great variety of fluids and substances whether cold or hot, free flowing or highly viscous, corrosive and/or abrasive, or containing hard or soft solids. A recent development of the Mono Pump is the introduction of metal stators which will extend its application to the problem of pumping highly viscous mixtures of temperatures up to 350° F. A new petrol driven pump for agricultural purposes is also displayed on the stand, as well as their standard range of "D" and "H" types which cover many of the requirements for the Mining, Chemical, Food, Brewing, Paper, Plating, Ceramic, Agricultural, Marine and Tanning Industries. Demonstration models on the stand will give a mechanical explanation of the interesting Hypocycloidal motion of the Mono Pump.

The Morgan Crucible Company, Ltd., will display, at Stand D.305/204, Birmingham, crucibles, basins, stands, muffles and covers, representative of the wide range of plumbago foundry equipment manufactured. Three Morgan Crucible Furnaces will be shown, namely—the Lift-out, Bale-out and Central Axis Tilting. The display of Morganite Carbon Engineering Parts in their various shapes and grades and the diversity of their applications will convey some idea of the industries served by this modern engineering material. Carbon Brushes for electrical machines, crane current collectors, trolley-bus collector inserts, and pantograph strips, all illustrate the advantages of carbon as a self-lubricating sliding current collector. Carbon welding electrodes are used for the carbon-arc welding of light gauge metals and stainless steels. Among all applications, the most important physical property, self-lubrication, is illustrated by Morganite carbon bearings, piston rings, pump seals, etc.

B. O. Morris Ltd., Coventry, will be showing at Stand No. D.515, Birmingham, flexible shaft machines ranging from $\frac{1}{16}$ h.p. to 2 h.p. and the Morrisflex 3, 4 and 6 h.p. Patent Non-Stop Polishing Lathe. The stand will devote an individual section displaying machines and equipment recommended, to each of a number of various trades. The equipment will include the MORRISFLEX Patent Backstand Idler, specially developed for Polishing Shops where back space is at a premium and will interest those who seek high-speed production methods.

Among the exhibits will also be seen the Double-Ended 8-in. Bench Grinder, another attractive addition to the Morrisflex range. The slim streamline body offers the minimum of obstruction to the operator when using either of the 8-in. grinding wheels and the adjustable tool rests giving a wide range of angles is another noteworthy feature. The machine can also be run as a small Polishing lathe (4-in. capacity—one side only) by removing the wheel guard, grinding wheel, sideplates and adaptor, and screwing on false nose.

The MORRISFLEX Pushabout, renowned for its usefulness in garage work, can now be seen on a new mounting which increases its mobility, and will appeal particularly to firms where a machine of this type is required for frequent use between different workshops.

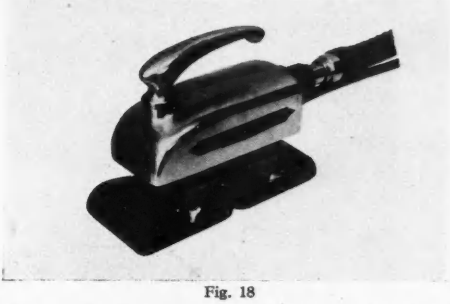


Fig. 18

The Double Oscillating Handpiece deals effectively with flat, concave and convex surfaces. This is shown in Fig. 18. It is designed for obtaining a fine finish, eliminating surface scratches and pressure marks, in both wet and dry sanding operations.

Murex Ltd. are again showing at Birmingham, at Stand D.709, in conjunction with their subsidiary companies **Murex Welding Processes Ltd.,** and **Protolite Ltd.**

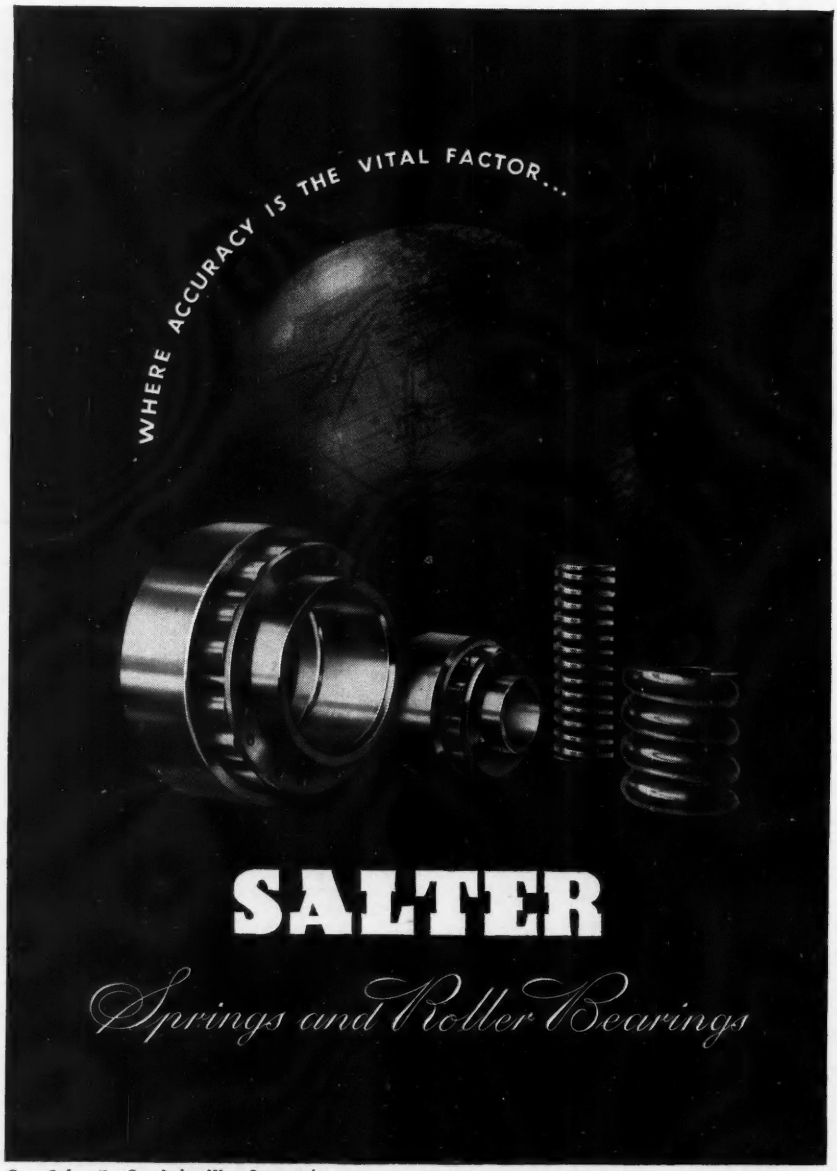
Murex Welding Processes Ltd. are manufacturers of arc welding equipment and electrodes, and Protolite Ltd. are the distributors of PROLITE hard metal tools, tips and wear-resisting parts.

A very wide range of metals, non-ferrous and ferrous alloys and salts of tungsten, molybdenum and vanadium are produced at the Rainham Works of Murex Ltd. and a representative collection of these will be on view. Among the list of products will be included Tungsten Carbide, as used for making PROLITE and other cemented tungsten carbide hard metals.

Various applications of the THERMIT process, used for welding and for making steel castings, will be displayed. Samples taken from sections of railway and tram tracks, welded by means of the THERMIT process, will be shown. There will also be displayed a number of small castings made by the Thermit process, together with photographs of the technique of production.

Aluminium-nickel-cobalt permanent magnets, produced by powder metallurgy methods, will be shown. It is possible to produce small and intricate shapes by this method.

Murex Welding Processes Ltd. will be exhibiting a comprehensive range of exhibits and an opportunity afforded to visitors of discussing technical problems. In addition they will be able to witness practical demonstrations of electric arc welding on the stand. One of the most interesting exhibits is the new Murex Safety Device, seen here in Fig. 19. This is a small, compact unit for A.C. welding equipment and is designed to reduce automatically the voltage at the electrode holder from the normal 80 or 100 volts to a safe voltage of approximately 30 volts within a fraction of a second of breaking the arc. The unit is self-contained, completely automatic, and requires no special technique. Some representative examples are also being shown of the wide range of Murex arc welding equipment, which includes petrol or diesel engine driven sets, transformer equipments and motor generators with either single or dual control.



Geo. Salter & Co. Ltd., West Bromwich M-W.157

See **STAND A407/306** AT THE B.I.F. Birmingham

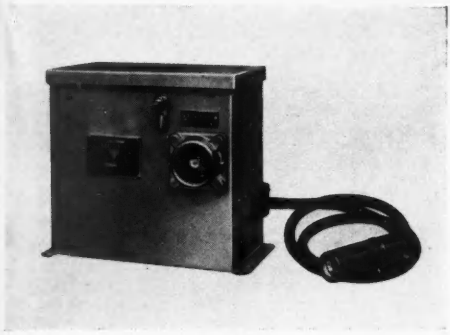


Fig. 19

New electrodes will be demonstrated from the extensive Murex range, which now covers over 60 different types. The electrodes exhibited include types for the welding of mild steel, high-tensile steels, heat-resisting steels, non-ferrous metals, cast iron, and a complete range of hard facing electrodes.

The exhibit is completed with examples of welded fabrications and a display of technical literature.

The Ozalid Company Ltd., London, will be exhibiting on Stand D707 and 606 their new Ozaprinter, a Photo Copying Machine for the economical and continuous production of prints, where output does not justify a large installation. It accommodates cut sheets or continuous rolls up to 40 in. wide. The conception of the whole layout has been to provide a machine simple to operate and of attractive design, which follows the current trend for improved office equipment. The light unit is one 1000 watt high pressure mercury vapour tube, of extremely long life under normal conditions; a full actinic intensity is assured for a considerable period. This is fitted axially within a revolving Pyrex glass cylinder. A 1/6 h.p. motor is fitted, driving a fully variable gear unit, with a positive action control—Speeds range from zero to 10 feet per minute. It is intended that this machine will be used as a table or bench model.

Fig. 20

Also exhibited will be a new Ozalid Developing Machine for large volume Printmaking, shown in Fig. 20. The features of this machine are as follows :— It is designed for use with any make of printing machine. It fully develops all Ozalid grades at constant speed of 12½ feet per minute, and handles cut sheets or continuous rolls up to 40 in. wide. The machine embodies an improved positive action ammonia feed control with micro-adjustment and neon lamp indicator. Provision is made for front or rear delivery at will. A larger dimension Print receiving tray is fitted for extra long prints and an adequate exhaust system ensures fume-free operation. Like their original " R " machine, this new machine will develop prints all day long without constant watching and adjustment.

Petrochemicals Ltd., showing at Stand B.17, Olympia, London, will be staffed by technicians who will be able to provide visitors with details of their products and processes. Manufacture of petroleum-derived chemicals has now started at their new plant at Partington, near Manchester. The chemicals will be marketed under the trade mark " CATARFX." The plant has an initial capacity of some 75,000 tons per year of finished products.

The Rapid Magnetting Machine Co., Ltd., Birmingham, are showing at Stand C.409, Birmingham, various types of their specialised Electro-magnetic Separating and Lifting Equipment used in connection with purification, extraction, reclamation, protection, power transmission and transportation problems. Magnetic equipment is a fundamental necessity wherever tramp iron or small ferrous impurities are present in processing, whilst it is also essential for the protection of grinders, pulverisers, crushers, graders and similar mechanical gear, in order to avoid damage to plant and consequent hold-up in production.

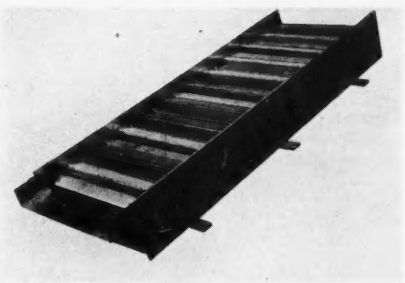


Fig. 21

Fig. 21 is the " Rapid " multi-self-cleaning chute type electro-magnetic separator for positive separation of coarse or fine iron from swarf, borings, etc. A range of " Rapid " Electro-Lifting Magnets will be demonstrated, showing how speedy and economical it is possible to lift and stack various materials. Of particular interest to Overseas Buyers will be the " Rapid " O.G. Magnetic Mineral Separator designed for the selective separation of feebly magnetic ores, i.e., Monazite Sands, Tin Sands, Iron Sands, Wolfram Tin, Carborundum, etc. A range of non-electric equipment will also be on view, including the " Rapid " " Permaflux " non-electric pulley. This pulley is particularly applicable for relatively shallow depths of feed. A device for work holding, the " Rapid" Magnaclamp, will also be demonstrated.

Sciaky Electric Welding Machines Limited will be exhibiting at Stand C.222, Birmingham, an entirely new design of Heavy Duty Projection Welding Machine Type P.A. 100. This plant is rated at 100 kVA nominal, and can be supplied for connection either to a single phase supply or a three phase supply. All

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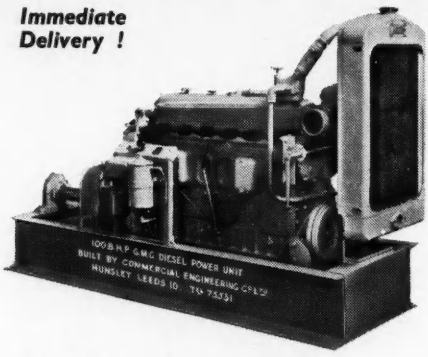

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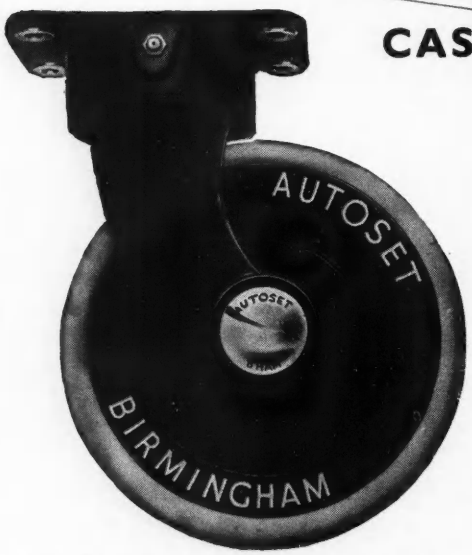

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control equipment, including the electronic ignitron contactor panel, is mounted within the machine frame, and timing either by resistance-capacitance method or by an electronic system can be incorporated. This Company will also be exhibiting two models taken from their latest design of spot and seam welders. These machines are the Type S.A.C. 25/2, 25 kVA spot and stitch welding machine and the Type R.A.M.U. 50 air operated, fully controlled, motor driven Longitudinal and Circumferential Seam Welding Machine. These machines are of ultra-modern streamlined appearance and all control equipment is built within the machine frame.

Turner Brothers (Birmingham) Ltd., will be exhibiting at Stand D.512, Birmingham, their T.B. Power Presses. These range from 6 to 20 tons, and several of the models will be fitted with the latest types of roll and dial feeds. A feature of particular interest to all saw manufacturers will be the Saw Notching Machine, seen in Fig. 22 herewith, which is being exhibited for

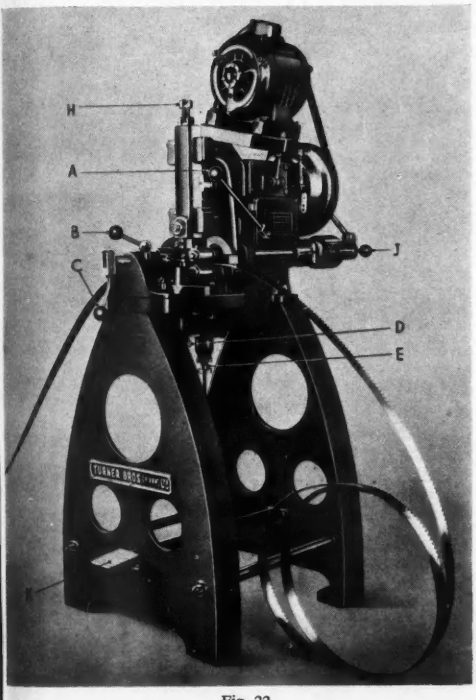

Fig. 22

the first time. This machine is capable of producing saws from material widths $\frac{1}{8}$ in. to 3 in., giving from three to twenty-five teeth per in. as required. Special attachments are available to cover taper saws and material up to 7 in. wide. Various Pressings, Moulds, etc., showing the quality of this firm's craftsmanship, will also be exhibited.

Wellington Tube Works, Ltd., Tipton, Staffs., will display, at Stand C.300, Birmingham, a selection of Tubes, Fittings and Tubulars, as well as a number of products incorporating tubular construction. Among the many exhibits showing the successful application of tubular fabrication principles, is a new and interesting patented Handrailing Joint of exceptional efficiency and neatness. There are also photographs of the Fabricated Tubular Shedding which was recently supplied for use at the Royal Agricultural Society's Annual Shows. Examples are also shown of Fabricated Flanged Pipework for pressure purposes, and also panels specially designed for Panel Heating. An important part of the display is a series of "Weldex" Heaters of capacities ranging from a small Unit to a heavy-duty Plenum, including a Gas-fired Air Heater and an entirely new range of Convectors.

One of the Company's subsidiaries, **Messrs. Job Edwards Ltd., Wednesbury,** are producing Stampings and Forgings for various purposes, and the specimens of these products which are exhibited have been specially chosen to show the wide range available.

A. C. Wickman Ltd., will be exhibiting at Stand D.416, Birmingham. The recently produced Wimet documentary film on the technique in application of Tungsten Carbide turning tools will be on exhibition. The film deals with most aspects of carbide tooling for normal workshop use and after describing the manufacturing processes involved in the production of the material, shows at length the principles behind the design of Wimet carbide tools and the effect of cutting rakes and angles on metal removal capacity and tool life. Cutting speeds, feeds and depth of cut are simply explained and a comparison of production with Wimet tooling and High Speed Steel tooling clearly shows the economic advantages of Wimet Tungsten Carbide tools.

The increasing adoption of Wimet carbide tools by industry generally is reflected in the wide range of tooling applications on show. Pottery, Textiles, Building, Mining, Plastics and Automative servicing are among the many industries represented in a comprehensive display of cutting tools in addition to the well-known range of Wimet tools for the engineering and sheet metal industries. Practical demonstrations of many of these tools will be given.

The qualitative and dimensional checking of finished components in almost any material is demonstrated on a Cornelius instrument on the Wickman Stand. Recent developments have considerably widened the scope of this instrument and a new model now available performs almost any industrial check on ferrous and non-ferrous materials. Examples of material analysis, crack detection, dimensional comparison and surface finish comparison are demonstrated.

S. Wolf & Co., Ltd., London, will be exhibiting at Stand No. C.603, Birmingham, their complete range of Wolf portable electric tools. This range comprises electric portable drills, screwdrivers, grinders, polishers, sanders, blowers, chisel mortisers, hammer kits, also a range of engine reconditioning equipment including valve seat grinders and valve and engine servicing kits, valve refacers and the "Mobilectric" engine workshop.

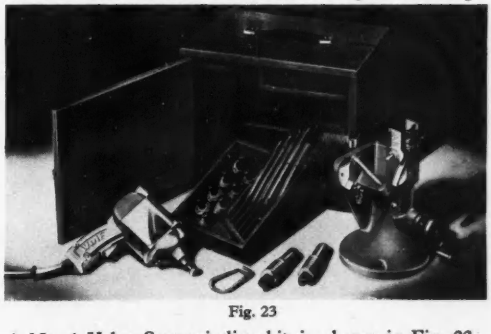

Fig. 23

A No. 1 Valve Seat grinding kit is shown in Fig. 23. Newly introduced machines of interest are their Universal Heavy Duty Drills, types WD4c, WD5, WD5c, WD6 and WD6c. Also on view will be the Type G.L.3 portable Electric Lathe Grinder for external and internal grinding, and two new valve seat grinding kits.

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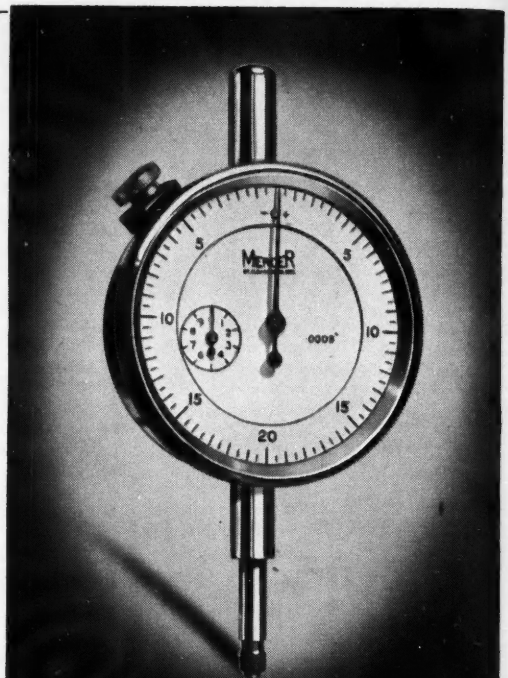

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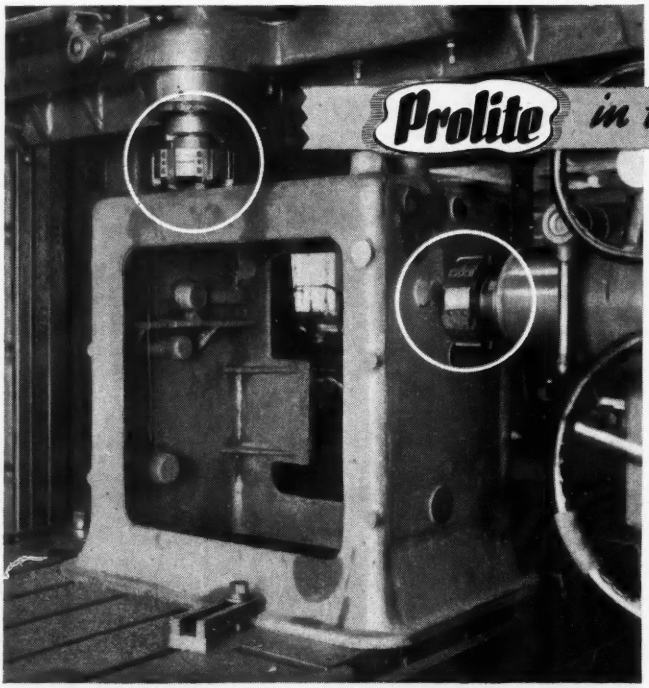

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NEWS OF THE MONTH

PERSONAL

Sir Edward Appleton has been awarded the James Alfred Ewing Medal of the Institution of Civil Engineers.

Dr. R. W. Bailey, consultant in the research department of the Metropolitan-Vickers Electrical Company, Ltd., has been elected a Fellow of the Royal Society.

Mr. W. J. A. Davies, O.B.E., M.I.N.A., a member of the Royal Corps of Naval Constructors, has been appointed Director of Merchant Shipbuilding and Repairs, Admiralty, in succession to Mr. S. A. McCarthy, R.C.N.C., M.I.N.A.

Hancock & Co. (Engineers), Ltd., well-known manufacturers of Oxygen Cutting and Profiling Machines who this year celebrate the 30th anniversary of their incorporation, announce the appointment to the Board of Directors of **Mr. A. V. Marshall** and **Mr. E. Seymour Semper, M.I.Mech.E.**

Mr. W. D. M. Lywood has been appointed manager of the Newcastle-upon-Tyne office of the English Electric Company, Ltd., in succession to **Mr. H. Ketton,** who has retired after twenty-seven years' service in that position. Mr. Ketton will continue to act in an advisory capacity.

Mr. F. Stanley Mockford, commercial manager of Marconi's Wireless Telegraph Company, Ltd., has been elected chairman of the Radio Communication and Electronic Engineering Association. **Mr. V. M. Roberts,** of the British Thomson-Houston Company Ltd., is the new vice-chairman.

Mr. Benjamin Mower, assistant manager of the test house at the Cleveland Works of Dorman, Long & Co., Ltd., has retired after 52 years' service with the company.

Colonel A. S. Osborne, O.B.E., M.C. (late R.A.O.C.), has been appointed director of the Council of British Manufacturers of Petroleum Equipment, 40 Palace Chambers, Bridge Street, London, S.W.1, as from April 1, in succession to **Mr. T. L. Bonstow, M.I.C.E., M.I.Mech.E., F.Inst.P.,** who, however, is remaining with the Council in the capacity of technical adviser.

Mr. John Dale Rabett, A.M.I.C.E., of 16 Plume Avenue, Colchester, is joining the Colonial Service as an executive engineer in the Public Works Department, Nigeria.

Mr. W. Redfern, the new President of the Manchester Association of Engineers, 20 Booth Street, Manchester, 2, was inducted into the chair by the outgoing President, **Mr. J. W. Curtis, M.B.E., A.M.I.Mech.E.,** on March 18.

Mr. H. L. Satchell, manager of the Rugby Works of the British Thomson-Houston Company, Ltd., and its associated factories at Peterborough, Leicester (Blackbird Road) and Nelson (Lancs.), has been appointed a director of the company.

The Board of Trade announces the appointment of Regional Controllers as follows :—Northern Region, **Mr. K. G. Sillar, M.I.E.E., A.M.I.C.E.;** London Region, **Sir Quintin Hill, K.C.M.G.;** South-Western Region, **Mr. Graham Glennie;** Eastern Region, **Captain H. K. Oram, R.N.** (Ret.).

The Director and General Secretary of the Institution of Production Engineers, **Major C. B. Thorne, M.C.,** has tendered his resignation on being adopted prospective Conservative candidate for Uxbridge.

Mr. Jack Williams, assistant area manager of the General Electric Company Ltd., at Cardiff, has been appointed area manager at Newcastle-upon-Tyne of the Company's North-Eastern area. He joined the company in 1910.

OBITUARY

It is with very deep regret that we record the death of Mr. E. P. Paxman, Managing Director of Davey, Paxman & Co., Ltd., who died very suddenly on March 25th, 1949. Mr. Paxman, who was born in 1901, was the son of the late Mr. James N. Paxman, founder of the above firm. He was educated at Oundle School, and thence went to Cambridge University, where he obtained a first-class honours degree in mechanical engineering. He had a period of training with Metropolitan Vickers Electrical Co. Ltd., and then entered the employ of Blackstone & Co. Ltd., Stamford. He joined Davey, Paxman & Co., Ltd., in 1926, and shortly afterwards became Chief Engineer. After acting as Director and then joint Managing Director, he became Managing Director on the association of the Company with Ruston & Hornsby Ltd., of which Company he also became a Director.

His sudden death at the early age of 47 will be a great national loss to the engineering industry as well as to his numerous personal friends in all parts of the world.

BUSINESS NOTES

Messrs. Lansing Bagnall Ltd., manufacturers of industrial tractors, platform trucks and trailers, have moved from Isleworth, to a new factory at Kingsclere Road, Basingstoke, Hants. (Telephone : Basingstoke 1010). Their London sales office is at Little St. Leonards, Mortlake, S.W.14. (Telephone : PRospect 4466.).

B.S.A. Tools Ltd. (Small Tools Division), Montgomery Street, Sparkbrook, Birmingham, announce that in future B.S.A. Golden Arrow Super Quality Drills will be supplied as their standard product at standard prices.

It has been proved that the Golden Arrow treatment makes for longer life of the drill and considerably reduces the cost per hole. All standard sizes are available from stock or early delivery.

LONDON EXHIBITION OF FLEXIBLE PACKAGING MATERIALS MAY 3rd TO 31st.

Pursuing its policy of introducing new materials and processes to designers, production engineers and sales executives, the Council of Industrial Design will hold, from May 3rd to 31st, an exhibition of flexible commercial packs and packaging materials in its exhibition hall, Murray House, Petty France, S.W.1.

The exhibition has been organised jointly by the Council, the Institute of Packaging and the Printing, Packaging and Allied Trades Research Association. Exhibits from over 60 firms will demonstrate some of the more interesting packaging in current use as well as many recent developments.

Three new processes will be shown publicly for the first time in this country. One overcomes the difficulty of fixing durable designs and lettering upon PVC film. Another prevents any form of metallic corrosion inside a sealed pack. The third effects a revolution in the manufacture of jute sacks by means of a circular loom.

Other exhibits range from pleated collapsible tubes and plastic bottles which can be squeezed by hand, to " wet strength " papers and PVC heat-sealed bags for oils and other liquids.

The exhibition is selective ; is not open to the public and there is no charge for stand space. Business may not be transacted at the exhibition but sales literature and technical data will be made available for reference.

GOVERNMENT MACHINE TOOLS SALES NEARING COMPLETION

As the Ministry of Supply Disposals of machine tools is nearing completion, all disposal centres for these goods have been closed on 1st April, with the exception of those in London and Birmingham.

The London centre will remain at its present address : Caxton House East, Tothill Street, S.W.1, but the centre at C.M.L. Buildings, Gt. Charles Street, Birmingham, will be transferred to the Daimler No. 2 Factory, Brown's Lane, Allesley, near Coventry.

Records of all machines on offer, irrespective of where lying, and existing facilities for purchasers to inspect machines and lodge offers will be available at both places.

Notices of forthcoming machine tool auctions will be announced at these offices, as well as in the Board of Trade Journal and Trade periodicals.

HEAVY NICKEL DEPOSITION BY THE BRAILEY PROCESS

Parts worn or accidentally machined undersize, can readily and safely be salvaged by Brailey heavy nickel deposition. Nickel can also be used to withstand heavy corrosive attack.

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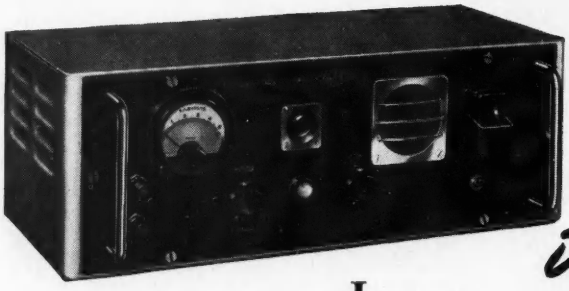

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SCOTTISH INDUSTRIES EXHIBITION, 1949.

This exhibition to be held at Kelvin Hall, Glasgow, from September 1 to 17, will be the largest and most comprehensive of its kind ever held in Scotland, devoting itself to Scottish-produced goods. Over 99 industries will be represented ranging from Engineering and Iron and Steel to Textiles and Consumer Goods, and every encouragement has been given to the small industries to display their wares in this Scottish shop-window.

Demonstrations and other attractions will be staged daily in the 25,000 sq. ft. arena inside the Exhibition Hall, and arrangements have also been made for a private industrial cinema seating approximately 50/60 persons—where firms with suitable films will be able to provide showings to their selected audiences. The exhibition will be a well-balanced presentation of the high standard products of modern Scottish industrial enterprise, embracing new industries as well as the old established ones.

I.C.I. FILMS FOR TRADE ASSOCIATIONS

Films play an important part in industry to-day. Consequently, the programmes of most trade and technical associations include sessions at which films are shown. It may interest these bodies to know that Imperial Chemical Industries Ltd. have films available, and are prepared to issue them free of charge to any official borrower.

All films are made for 16 mm sound projectors. Secretaries of trade and technical associations can obtain them, or get further information, from the I.C.I. Film Library, Bolton House, Curzon Street, London, W.1.

BRITISH STANDARDS

(Copies of British Standards may be obtained from the British Standards Institution, 24 Victoria Street, London, S.W.1.)

General Guidance in Sampling Non-Ferrous Metals (B.S. No. 1499 : 1949). There is no entirely reliable method of taking a representative sample from a bulk of solid metal without re-melting since there is almost invariably some segregation in the bulk. Re-melting may, however, lead to the loss of oxidizable or volatile constituents or contamination of the sample. It is, therefore, often desirable in practice to obtain as representative as possible a sample from solid metals.

The B.S.I. has just issued B.S.1499, General guidance in the sampling of non-ferrous metals. The general recommendations are not intended to apply to metals covered by any British Standard which may itself include sampling instructions, but the publication will be of value until such time as British Standard methods of sampling and analysis have been issued in respect of all the major non-ferrous metals. Price 1/-.

Glossary of Process Control Terms (B.S. No. 1523 : 1949). This British Standard Glossary of Terms used in Process Control forms Section Two of a comprehensive glossary which is planned to cover terms used in automatic controlling and regulating systems of the closed-loop type, namely systems in which the actual value of the controlled condition is continuously compared with the desired value.

Section Three, covering the nomenclature of position control servo-mechanism is now in course of preparation and this will be followed by Section Four, covering automatic regulators. Section One of the glossary will contain those terms common to all automatic controlling and regulating systems of the closed-loop type and will be prepared when the other Sections have been completed.

The terms and definitions given in Section Two have been accepted by both manufacturers and users of automatic control apparatus. There has hitherto been a degree of conflict and ambiguity in the nomenclature and it is hoped that these standard terms and definitions will find general acceptance and thus provide a basis for a unified nomenclature for use in the theory and practice of automatic control. Price 2/6.

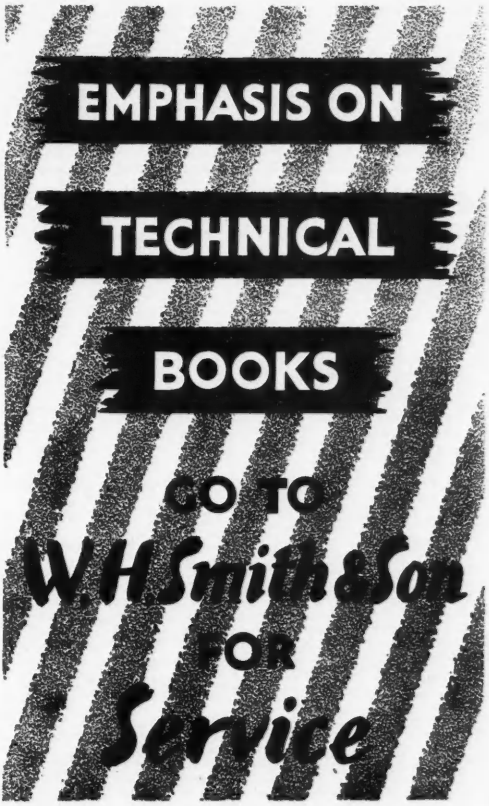
It is intended to review this standard after a period of twelve months in order to incorporate any alterations or improvements which its use may have rendered desirable, and the Institution will be glad to receive any suggestions for consideration.

Tung Oil (Types F. & M.) (B.S. No. 391 : 1948). This British Standard is a revision of B.S.391 : 1936, which applied to tung oil derived from *Aleurites Fordii* (Type F.). In December, 1940, an emergency war revision was issued covering oil derived from *Aleurites Montana* (Type M.). The purpose of the present revision is the issue of a British Standard applying to oil from both species and specifying only where necessary alternative values and properties for each type.

This standard lays down the quality of the material by specifying the limits for volatile matter, colour, specific gravity, refractive index, iodine value, saponification value, acidity, unsaponifiable matter, gelation time and insoluble bromide content. The methods of sampling and testing are described, and these have been brought into line with British Standard tests for oils and fats, in course of preparation. Price 2/6.

Synthetic Resin (Phenolic) Moulding Materials (B.S. No. 771 : 1948). A revision of B.S.771, "Synthetic resin (phenolic) moulding materials," is of unusual interest, not only because of the wide use of phenolic moulding materials, but also because this Standard is based on statistical principles. The reason for the adoption of this basis for the Standard is the knowledge that little confidence can be placed in the results of tests on a small number of specimens made from a batch of materials, when these results are considered on their own.

The Standard therefore relies on continual control of the product during manufacture. It defines basic values for the properties of phenolic moulding materials, and specifies the evidence which will be accepted as indicating conformity with those basic values.



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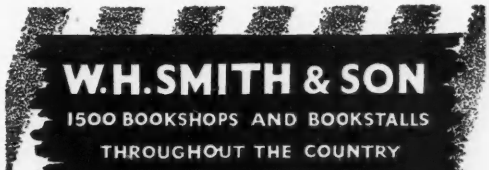

The Standard may nevertheless be used for accepting or rejecting a single batch of moulding material, in any case when it is desired to do this.

The Standard specifies mandatory requirements for the following properties of eight types of moulding materials: tensile strength, impact strength, surface resistivity, volume resistivity, heat resistance, power factor and permittivity.

The Standard also specifies optional requirements, any of which may be invoked by a purchaser, for water absorption, plastic yield, electric strength, and acetone-soluble matter.

Methods of test for each of these properties are given and the Standard also includes methods of test for eight further physical properties of these materials. Price 5/-.

Classified Advertisements.

The Rate for all classified advertisements is 6d. per word ; in bold print 9d. per word ; minimum order 6s. Box number advertisements 1s. extra. Instructions together with remittance must be received not later than the 3rd of each month for advertisements to appear in the same month's issue.

SITUATIONS VACANT

MECHANICAL DRAUGHTSMAN required for duty in London Office of large Oil Company ; apprentice trained and with qualifications to not less than H.N.C. or equivalent. Preference to applicants familiar with design and lay-out of heavy plant and Diesel driven pumping stations, refineries, steam power plant and structural steel work. Age : 30-40. Salary according to experience.—Write, quoting No. 305, to Box 2764 c/o CHARLES BARKER & SONS, LTD., 31 Budge Row, London, E.C.4.

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Candidates, desirably not older than 34 must possess extensive practical experience in works specified including at least five years in D.O. Technical School background and qualification to not less H.N.C. Salaries incremental from £700 plus allowances £300-£600 dependent on marital circumstances ; and free furnished quarters.—Write, quoting No. 292, to Box 2751, c/o CHARLES BARKER & SONS, LTD., 31 Budge Row, London, E.C.4.

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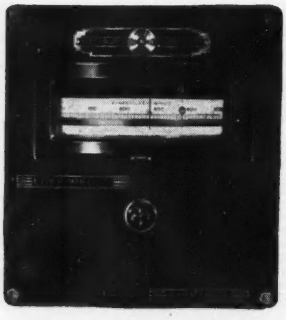

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